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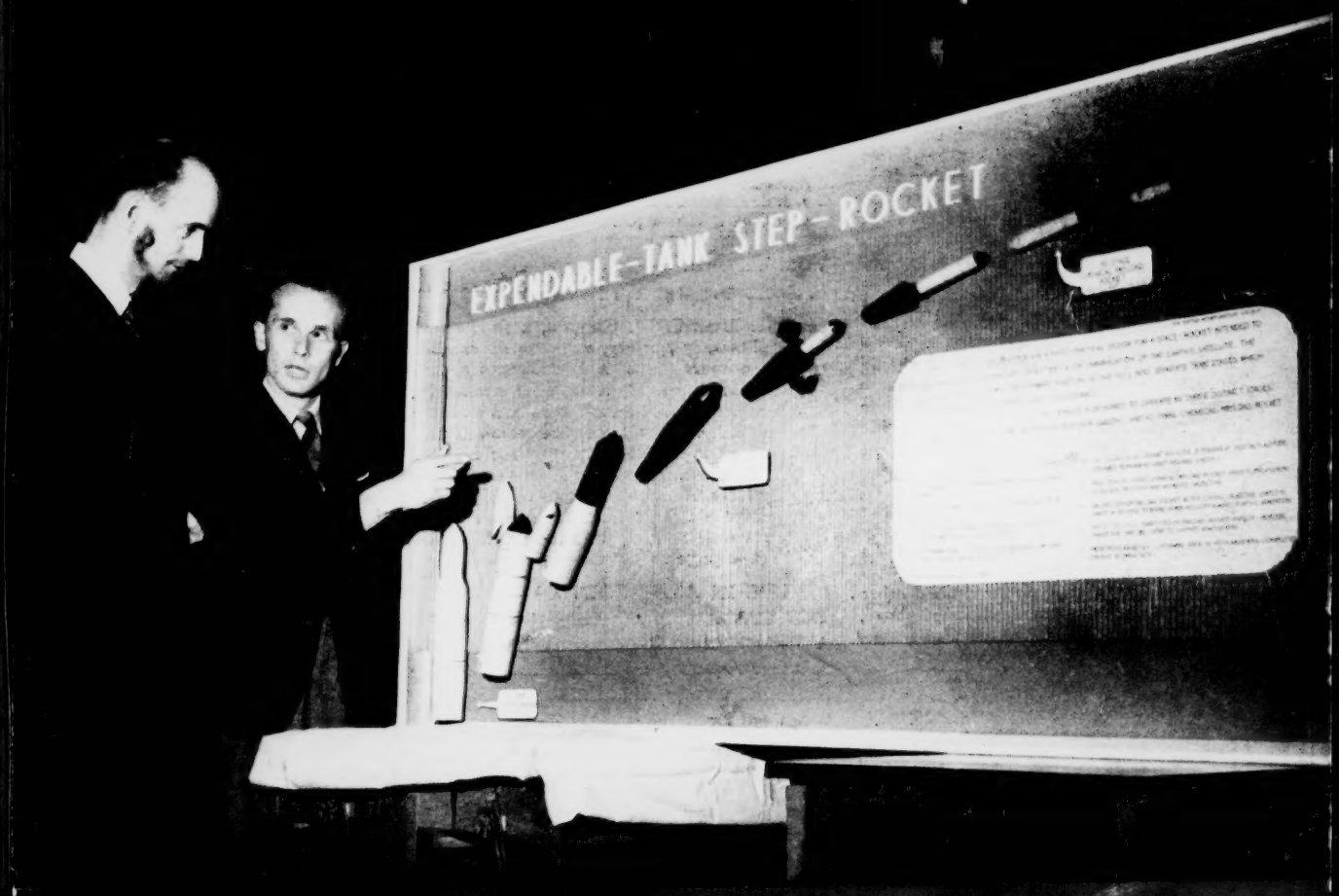

Three-stage space rocket

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A Proposal for The Christmas Star

Northern and Southern Star Charts

LETTERS

Sir:

I wonder if some of your readers can help me identify the stars Mu, Eta, and (Flamsteed number) 1 Geminorum. There appears to be disagreement among astronomical writers as to their names.

Olcott[1] gives the name Tejat to Mu and Propus to Eta. In the latter instance he agrees with Webster's **International Dictionary,** which, however, gives no proper name to Mu.

But these two sources disagree with writers of the early 19th century. Burritt[2] calls Eta Tejat and 1 Propus. McKay[3] agrees with Burritt on Propus (to which he gives the letter H), but has no names for Mu and Eta.

This sort of thing gets complicated after a while, so perhaps it can best be demonstrated by the adjoining table.

In a sense, no such confusion should exist with regard to Propus. It is one of the few star names of Greek origin, and the meaning should therefore be clear. It is a combination of two words, **pro,** preceding, and **pous,** foot, so that it can be translated as "the preceding foot."

But with just as much justification, it could easily be translated "preceding the foot" — precisely as Procyon is sometimes translated "the preceding dog" and sometimes "preceding the dog" — Sirius being called **kuon,** dog, in Greek. It is my belief that most authorities agree on the latter sense: "preceding the dog," in the case of Procyon, and, by analogy, it appears that Propus should be attributed to the star 1 rather than Eta.

It is unfortunate that the Trapezuntius **Almagest,** from which the designations in the table have been taken, is in Latin. Had it been in Greek, I should probably have had no problem, since the name Propus probably appears in the Greek manuscripts. I have been unable to examine (or even to find!) a copy of the **Almagest** in Greek.

As to the name "Tejat," I have no opinion either way. I do not know what the name means, although I think it may possibly stem from the same root as the Arabic word for "bottom" or "below."

Needless to say, I have examined other authorities besides those mentioned above, but find the data either omitted or equivocal.

SIDNEY I. SCHEUER
675 West End Ave.
New York 25, N.Y.

Source	*Date*	*Mu*	*Eta*	*1 Gem.*
Olcott	1914	Tejat	Propus	
Webster	1923		Propus	
Burritt	1843		Tejat	Propus
McKay	1801			Propus
Lalande[4]	1771	"heel of Castor"	"foot of Castor"	
Ptolemy[5]	(1528)	"which is fixed in the same foot following (Eta)"	"which is the end of the foot of the preceding Twin"	"which precedes the end of the foot of the preceding Twin"
de la Hire[6] (map)	1770	(shown on map as ankle of Castor)	(shown on map as heel of Castor)	(shown on map as toe of Castor)

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COVER: Kenneth W. Gatland, a fellow and council member of the British Interplanetary Society, explains an exhibit of the "orbital techniques" involved in the operation of a combination chemical-atomic step-rocket to the moon and back. Stage I is a chemical booster (white) to lift the load through the denser regions of the atmosphere and build up velocity. Stage II is an atomic booster (black), which places the rocket in a "permanent" orbit around the earth, from which it is relatively easy for Stage III (7), the chemical payload rocket, to reach escape velocity from the earth and achieve the objective of circumnavigating the moon. Stage III (8) is used after leaving the objective to provide reverse thrust against the earth's gravitation, and (9) provides reverse thrust for safe re-entry into the earth's atmosphere. Photograph by Pictorial Press. (See page 27.)

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BACK COVER: The moon, first objective of interplanetary flight, photographed at last quarter (age 22.06 days), October 26, 1937, at Lick Observatory by J. H. Moore and J. F. Chappell, using the 36-inch refractor with full aperture, exposure 0.75 second. Lick Observatory photograph.

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Trends in Astronautics

By Kenneth W. Gatland

Design Department, Hawker Aircraft, Ltd.

WITHIN RECENT YEARS, the rocket has become a research instrument of immense value. The adaptation of the German A-4 (V-2) rocket for high-altitude sounding by the United States armed forces in 1946 and the subsequent development, in America, of rocket vehicles such as the WAC Corporal and Aerobee have already led to signal advances in many fields of science.

Whereas the ceiling for direct atmospheric investigation was previously limited to 25 miles, the maximum altitude that could be reached by free balloons, the rocket is now permitting research to extend almost into space itself. The introduction of A-4 immediately raised the level of observation to 70 miles, and records have since been effectively telemetered from altitudes above 100 miles. In February, 1949, we witnessed the first demonstration of a high-altitude step-rocket in which a V-2 was used as a booster for a WAC Corporal. The resulting climb of the final step to a point fully 250 miles from the earth's surface gives an indication of the vast possibilities which now exist.

Here, indeed, we have already the basis of future flight into space, for as rockets of greater range are produced for altitude sounding, so will the improved performance help to obtain three initial targets in the development of astronautics: the close-orbit earth-satellite vehicle, the extraterrestrial instrument vehicle, and a one-man research rocket.

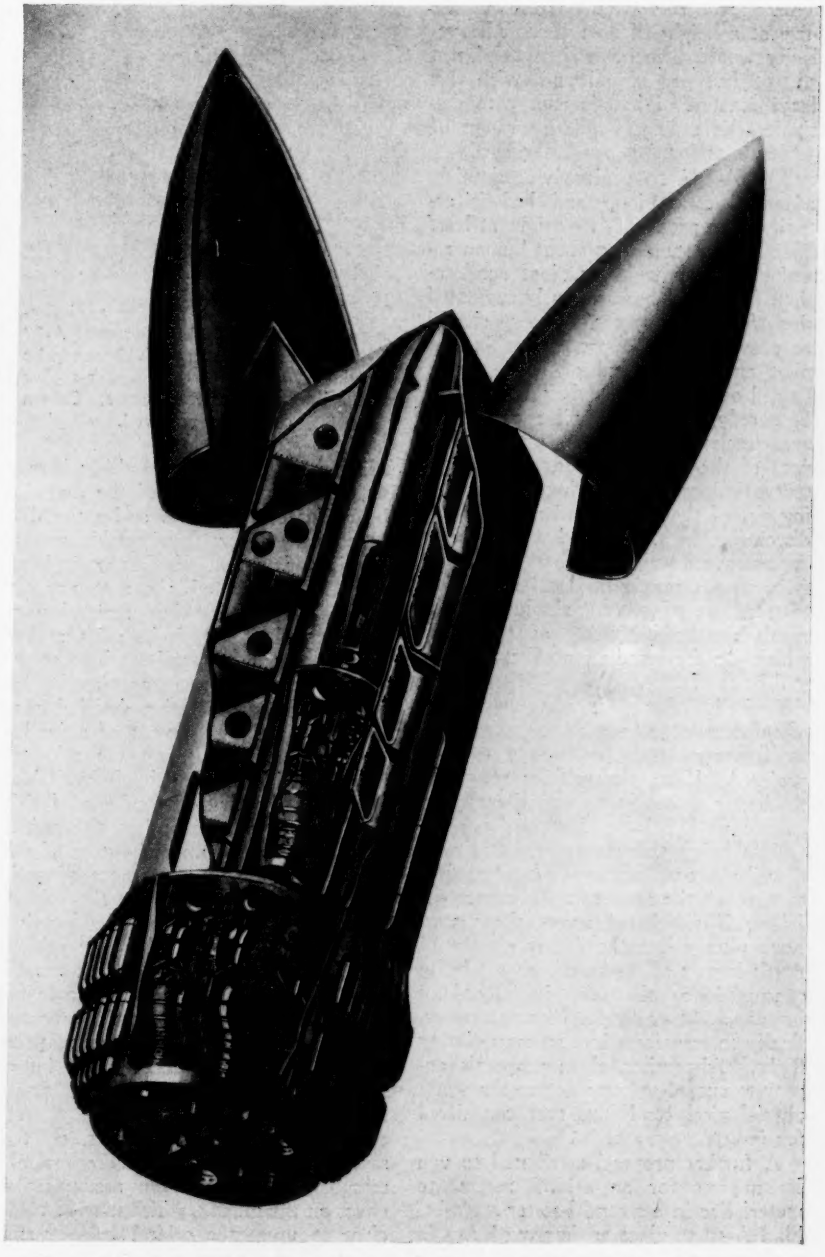
There is, in fact, already existing in the United States a program for the first,[1] while Smith and Ross of the British Interplanetary Society have given us an interesting conception of a vehicle to test human reactions to rocket flight, using A-4 as a basis, which it is reasonably claimed could be produced after five years preliminary experiment.[2]

These first manned rockets will enable the physiological problems related to acceleration and zero gravity to be studied directly. Investigation of the occupant's ability to carry out certain duties ascribed to him in the testing procedure under the most adverse of these conditions will be possible and improvement made to the means already devised to counter possible ill effects.

The space rocket may therefore be expected to evolve to a well-defined plan and not, as is so often inferred by the lay press, in a single "do-or-die" attempt to navigate moonwards. In fact, the much-vaunted "moon expedition" will be the *climax* rather than the beginning of a series of initial objectives in the development of scientific rocketry, and an analysis of the situation related to present standards of engineering and chemistry shows that its realization is probably still the best part of half a century away.

The establishment of an instrument-carrying rocket in a close orbit around the earth is clearly the initial target. The program in America to develop such vehicles was initiated in 1946, after examination had been made, at Peenemunde and other rocket research centers throughout Germany, of reports and design recommendations, and through the interrogation of prominent technicians by United States and British intelligence teams.

One of the more interesting design studies found in Germany was, of course, the A-9/A-10 project, in which



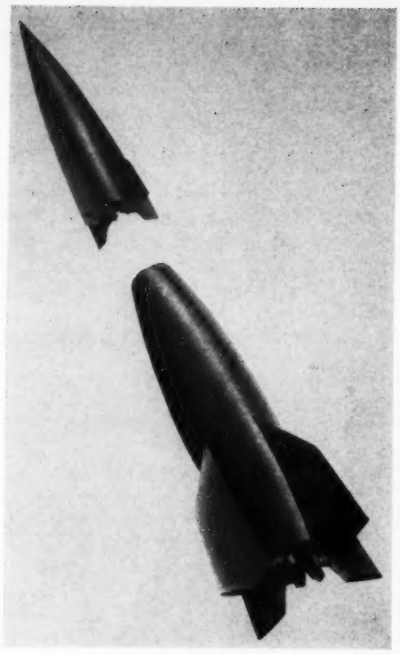
Expendable construction is here exemplified in a three-step rocket designed by the author for a close-orbit earth satellite. The weight of the rocket leaving the ground is 325,000 pounds; the instrumental payload of the final step is 110 pounds. The first parts jettisoned are the nose tanks shown flying apart in this model. Crown copyright reserved.

it was sought to extend the range of a modified, winged A-4 to the Atlantic seaboard of the United States. This was to be achieved by providing the rocket with a 68-ton booster, intended to reach the "all-burnt" condition at an altitude of 80,000 feet and give the A-9 a starting velocity of approximately 3,900 feet per second. After the booster had jettisoned, the winged rocket, continuing the climb, would reach a final velocity of 9,200 feet per second and, being then in highly rarefied atmosphere, the missile would follow a ballistic curve. Returning to denser air, aerodynamic controls would terminate the dive at a height of 28 miles. The velocity would then have risen to almost 11,750 feet per second and, with this large amount of kinetic energy to dissipate, the estimated gliding range of 3,000 miles for A-9 can be believed.

The A-9/A-10 project was a fairly advanced conception,[3] and had it actually been produced, we might at least have known something about human reactions over a wide range of acceleration, for it had been seriously suggested that, for test purposes, the A-9 should be provided with a pressure cabin and pilot and at the end of its flight be landed on a conventional undercarriage. Not only would the pilot experience zero acceleration conditions over the free path of the trajectory but, of course, a severe induced "g" during the flattening out of the dive. And added to his discomfort at this period would be a rather warm cabin, arising from skin friction. A maximum local stagnation temperature of 7,000° absolute would result at the beginning of the glide which, despite reradiation effects, would still be severe.

A similar, though in some ways even more drastic technique was suggested by Saenger in his supersonic bomber project.[4] Here, the vehicle, returning to denser atmosphere, was literally to bounce on the lower layers of the air and in being thrown upward again to describe a sort of wave-shaped trajectory, much the same as a flat stone will follow if ricocheted across the water. Each plunge into the denser air would result in part of the kinetic energy being consumed, so that the initially long jumps would gradually become shorter, finally to transform into an even gliding flight. Altogether, these proposals appear to exceed to some degree the worst physiological conditions ever considered for *interplanetary* flight.

A further proposal attributed to von Braun was for an orbital rocket, to materialize in a second booster stage behind A-10 to place an improved A-4 in a circular orbit at 400 miles. At that altitude the final rocket would be brought to horizontal flight where, balanced against gravity, it would remain. The rocket's velocity parallel to the surface is the square root of $g\,r^2/s$, where g is the mean gravitation of the earth, r the radius of the earth, and s the distance of the rocket from earth's center.



The largest rocket to receive engineering consideration, the German A-9/A-10. A modified winged V-2 was to be provided with the 68-ton booster rocket in the lower half of the picture. Crown copyright reserved.

It is evident that the first example of an orbital rocket will be a step-rocket with a very modest instrumental payload, possibly to reach its orbit at between 400 and 500 miles. The many practical problems accompanying its design are already receiving detailed consideration, and as these are of a fundamental scientific nature some relevant reports will be made publicly available.

One of the first by-products of this work is a comprehensive theoretical analysis of the nature and extent of the atmosphere.[5] The importance of such investigation is obvious, for the orbital rocket is effective only in its location "outside the atmosphere." The vehicle will exist as a satellite without expenditure of power only when there is no drag along its orbital path. Whereas the density of the atmosphere may be insignificant on the flight of an interplanetary rocket because of its small traverse time, the orbital rocket will travel for months, even years, on the same path and even an infinitesimal atmosphere would have an accumulative effect on the missile, which may be sufficient to upset the orbital balance and ultimately to cause its return to earth.

In developing any study of space flight, one is often confronted by questions which to the layman appear to be the last word in logical contempt. How, for example, can we discuss so calmly a moon flight extending 240,000 miles when the farthest we have so far been able to project a rocket is 250 miles? Clearly, to the uninformed, this does seem a most plausible argument. With space flight, however, one must emphasize that, given unlimited time, it is not *distance* that matters but ***velocity***, for a rocket that can attain a minimum of seven miles per second will defeat the earth's gravity and never return.

This velocity can effectively be built up by using a series of chemical step-rockets. The boosters jettison progressively, contributing a high fraction of escape velocity to the small instrument rocket in the nose that achieves final release from the earth. Having served their purpose in building up velocity the boosters, of course, drop back to the ground. Meanwhile, the final step coasts across space without any further expenditure of energy.

Thus, the stage beyond the orbital rocket may be a guided missile either to strike the moon's surface or, more sensibly, to take up an orbital path around it. The latter result would, of course, be more exacting in the control technique but nevertheless infinitely more worthwhile as a scientific experiment. It may even be possible, with comparatively light equipment, to transmit radio pictures of the lunar surface back to the earth, including large areas that are hidden from our direct view. However, this interesting prospect is not likely to arise very early in the development of space missiles because of the heavier payload and the delicate control and telemetering techniques involved.

A paper by Malina and Summerfield has shown that escape velocity can be obtained by guided missiles with any number of the available propellants by proper choice of the number of steps.[6] As an example, an acid-aniline rocket having a gross mass of 823,000 pounds and consisting of five steps could project away from the earth a payload of 10 pounds. Alternatively, an acid-aniline rocket having 10 steps could produce the same result with a gross mass of 136,000 pounds. In both these cases, the structural factor,

$$\frac{\text{structural weight}}{\text{structural weight} + \text{propellant weight}},$$

was taken as 0.25. Proportionately better initial takeoff masses are derived in other selected cases using oxygen-ethanol and oxygen-hydrogen. For the last, the structural factor was increased to 0.33, five steps requiring only 8,320 pounds at takeoff.

The instrumental device proposed, which it was thought could be built within the 10-pound limit, was a small radar-beacon transmitter and an electrical pickup for measuring a single quantity — cosmic ray intensity, for ex-

ample. Radar signals could be sent to such a rocket during flight by means of a ground transmitter similar to that which has already been used to reflect back echoes from the moon. The radar beacon in the rocket's final step is intended to "reflect" the signal back to the receiver on the earth, thus providing data on the missile's trajectory. The values of cosmic ray intensity taken during flight could be incorporated in the return signal from the radar beacon.

This possibility alone puts an excellent case for the early development of extraterrestrial rockets. With the further prospect of a light regenerator, converting solar heat to electrical energy in a continuous operating cycle, transmission between the rocket and the earth should be possible over much longer periods.

The reduction in mass for oxygen-hydrogen fuel as compared with the acid-aniline five-step rocket emphasizes the importance of developing practical high-performance rocket systems. With careful design, however, experiments of a unique and fundamental nature could effectively be carried out in interplanetary space with present-day conventional propellants. It is, of course, likely that such research vehicles will arise from the earth-satellite studies, for once even a primary orbital vehicle is established, the step beyond that to a guided missile capable of liberating itself completely from the earth is comparatively small.

To obtain these deeper penetrations into space will require not only multiple step-rockets but even more drastic techniques, such as expendable construction of the individual steps, where the projection of heavier payloads is involved.[7] It is proposed to break down the forward portion of the rocket hull into separate tank stages which jettison progressively as propellant is consumed. Each stage consists of two half-cylindrical tank bays with integral structure which on assembly form an efficient hull.

The component tanks are locked together with explosive ties and pressure balance is provided between them, allowing the use of light diaphragms for the backing panels. The separate stages have conical noses, both to afford some streamlining effect in the early part of the ascent, and to provide a light method of jointing, since all tanks are faced together. End loads would normally be transmitted through external jointed longerons to which the tank bays are directly anchored. An example of the type of construction envisaged is pictured here.

In the conventional rocket, such as A-4, and more significantly with the simple step-rocket of which the A-4/WAC Corporal is an early example, the payload is carried in the nose of the rocket. Therefore, the tank structure has to support, in addition to its own weight plus that of propellant, the loads induced by the payload which, of course, increase as acceleration increases. However, in the case of the expendable rocket, the payload is supported directly by the motor thrust mounting and the tank structure has to support merely its own weight plus propellant. In addition, the tanks and supporting structure, which are integral, are jettisoned immediately they are emptied of propellant, thereby eliminating the need for accelerating unnecessary dead weight in the individual steps.

Whereas it is theoretically possible for a pilotless rocket to escape from the earth, the same cannot yet apply to man-carrying vehicles. Indeed, the power requirements for manned interplanetary flight are so great, principally because of the need for the vehicle to carry return fuel, that chemical propellants may never be adequate.

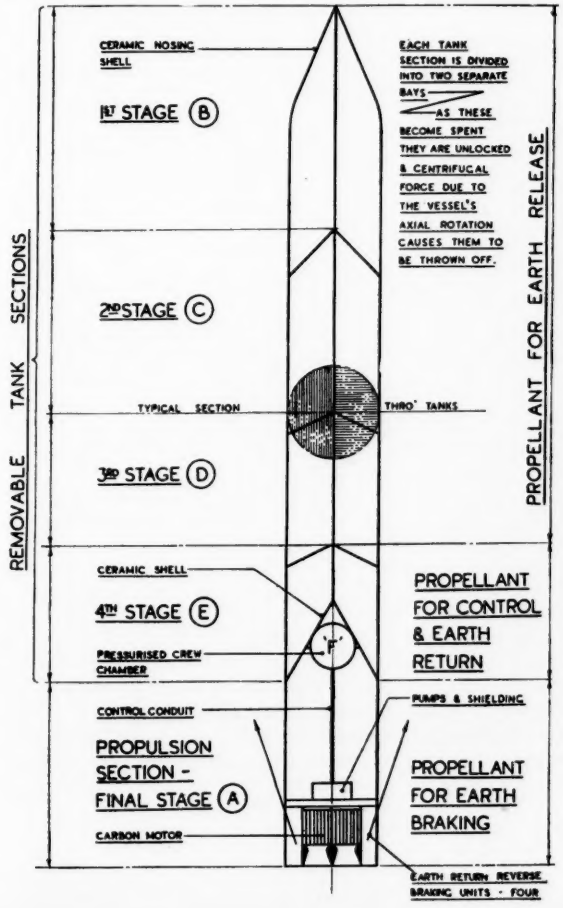
The application of what have become known as "orbital techniques" may help to relieve this situation.[8] The idea is simply that pilotless rockets would be used to build up a store of propellant in a stable orbit around the earth, which thus would represent a substantial potential energy toward gaining release velocity. If, for example, the required altitude is 500 miles, the propellant would be delivered into the orbit and stored at a velocity of 18,600 miles per hour.

The actual escape vehicle, containing crew and equipment, would then be made to rendezvous in the orbit with the "tankers," when the propellant would be transferred. There is the further possibility, with regard to a future moon flight, of sending pilotless "tanker" rockets into a circumlunar orbit.

Even assuming the use of an applied form of atomic energy,[9] it appears likely that orbital techniques will still play a prominent part. Indeed, it is in a combination of atomic and chemical drive that we may find our main solution.

The type of vehicle envisaged is a composite rocket (see the front cover) comprising a main propulsion stage, incorporating the atomic reactor, and a small chemical rocket which contains the crew. These rockets are first established in a suborbit of the earth, being driven out as complete units or possibly, in the case of the former, assembled in space from prefabricated sections. The atomic section of the vehicle is employed purely as a means of propulsion between planets, entering a suborbit at both ends of the flight; landing is achieved by the small chemical rocket in the nose.

After completing the mission, the


CERAMIC NOSING SHELL
1ST STAGE (B)
2ND STAGE (C)
TYPICAL SECTION
3RD STAGE (D)
REMOVABLE TANK SECTIONS
EACH TANK SECTION IS DIVIDED INTO TWO SEPARATE BAYS
AS THESE BECOME SPENT THEY ARE UNLOCKED & CENTRIFUGAL FORCE DUE TO THE VESSEL'S AXIAL ROTATION CAUSES THEM TO BE THROWN OFF.
THRO' TANKS
PROPELLANT FOR EARTH RELEASE
CERAMIC SHELL
4TH STAGE (E)
PRESSURISED CREW CHAMBER
PROPELLANT FOR CONTROL & EARTH RETURN
CONTROL CONDUIT
PUMPS & SHIELDING
PROPULSION SECTION - FINAL STAGE (A)
PROPELLANT FOR EARTH BRAKING
CARBON MOTOR
EARTH RETURN REVERSE BRAKING UNITS - FOUR

In July, 1948, the author published this diagram of an expendable-tank step-rocket designed for a piloted circumnavigation of the moon. It is conceived as having only one power unit, using propellant drawn from tank sections which expend successively from the nose. Rotation of the rocket furnishes the centrifugal force needed to detach the tanks when their content of fuel is exhausted. The pressurized crew chamber houses the crew, controls, provisions, and the like, and it can be detached and landed by parachute once the main vessel has returned to the atmosphere. Courtesy, "Journal" of the British Interplanetary Society.

chemical rocket relinks with the parent vehicle which propels it back to a circumterrestrial orbit.

In the case of a moon flight, a vertical descent to the lunar surface is entailed, using reverse rocket braking in conjunction with a radar altimeter and landing legs; the final return to earth, on the other hand, would involve both rocket and aerodynamic braking, methods of approach which are not easily satisfied by the same vehicle. It is possible, therefore, that a form of rocket glider (similar to the German A-9), previously brought up into the orbit, would be employed at the earth end, and into this the crew would be transferred after the two vehicles had been brought to proximity. The complete composite rocket would thus be retained in space and after being serviced and refueled it could be used again.

The successful application of these techniques, of course, presupposes the development of intricate guidance and control equipment. It must be remembered, however, that an orbital or satellite rocket would exist in a condition of free gravitation. So long as the location system were sufficiently accurate for the two vehicles to be placed in matching orbits and homed to proximity, their relative speeds could be brought to zero and they would remain together. A direct linkage might then be achieved with no more elaborate equipment than a small line-carrying rocket fired from one vehicle to the other, perhaps homing automatically into a target cage. Then, not only could propellant transfer be achieved and space-suited crew members exchanged but two components of a composite rocket might fairly easily be joined. If necessary, it would be possible for men to work outside the vehicles and to move themselves around the area with the aid of miniature rocket units.

The unique properties of the suborbit are not widely appreciated, and although their consideration may seem reminiscent of science fiction, the whole theory is nevertheless clearly defined. The development of rockets over the coming decades may therefore introduce the possibility of a meteorological station of unique coverage; an astronomical observatory with greatly improved visibility; a radar beacon; a television relay station or a set of three stations 120 degrees apart to serve the entire planet; chemical and biological research laboratories, with extreme temperatures and a "hard" vacuum available.

Concerning the effect of astronautics on human society, it is asked, for example, "Why fly to the moon?" It is obvious, of course, that the moon is the nearest body in space and the easiest to reach. But to appreciate the reasons for space flight beyond the purely scientific aspect one must understand the motives that underly all human conduct.[10] The predominant impulse of men throughout the ages has been the quest for positive knowledge. Some have embarked on daring explorations across the world while others have made equally momentous journeys with pencil and paper. The urge to discover, to explore, is a primary impulse.

Man's relentless endeavors have resulted in the earth giving up many of its secrets, and interest is now ranging to worlds beyond. But the quest for knowledge and the advancement of science, important though these may prove, are not necessarily the primary benefits. It is in this realization that astronautics and astronomy should travel a common road. Flight into space will not only remove the limitations that have hitherto been imposed on instruments by the earth's atmosphere, opening up entirely new fields for scientific study, but through the interpretation of astronomical knowledge it should greatly assist in raising the level of human consciousness. In this writer's opinion, an enrichment of experience far exceeding anything Man has ever previously known must be the cardinal benefit of space flight.

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Yale-Columbia Southern Station to Move to Australia

Australian astronomical activity has been expanding in recent years. The Commonwealth Observatory at Mt. Stromlo near Canberra, under the direction of Dr. Richard van der Riet Woolley, promises to become one of the important astronomical centers in the Southern Hemisphere. Within the next few years, a 74-inch reflector and a powerful Schmidt telescope will be added to the observatory's equipment.

As a result of Dr. Woolley's initiative, other institutions have been invited to set up their instruments on Mt. Stromlo. Among these, Yale and Columbia universities and the Swedish University at Uppsala have decided to accept the Australian offer. It was announced recently that the Yale-Columbia southern station in Johannesburg, South Africa, will soon be transferred to Mt. Stromlo.

The two American universities had been searching South Africa for a new location for their southern station when the Australian government extended its invitation. The rapid growth and industrialization of Johannesburg caused city lights and smoke to hinder astronomical observations. The new location should never be similarly hampered, for a recent act by the Australian parliament forbids the industrial or residential development of the area.

The principal instrument of Yale-Columbia is the 26-inch Yale telescope, in operation since 1925 on the grounds of the University of the Witwatersrand. Since 1946 the station has been operated jointly by Yale and Columbia. The Australian government will construct a dome to house the telescope, which will be shipped as soon as the new housing and living quarters for observers are available.

All of the institutions co-operating in the new plan will install equipment of their own and maintain staffs in the observatory. The astronomers will work independently, but will have the benefit of the pooling of instruments and the interchange of ideas through scientific discussion. The proximity of the newly founded Australian National University in Canberra is expected to add to the significance of Mt. Stromlo as an astronomical research center.

It is hoped that in an exchange of students Australian students will come to the United States for a year or two of specialization in physics, mathematics, and other work of basic importance to astronomers, and American candidates for the doctor of philosophy degree will go to Australia to make astronomical observations in the southern skies.

Yale University Observatory has recently completed its zone catalogues, covering to the 9th magnitude one half of the sky, from $+30°$ to $-30°$, a project that has been under way for nearly 25 years, directed by Dr. Ida Barney. Positions were measured for 128,000 stars, mostly on South African plates.

TERMINOLOGY TALKS

J. Hugh Pruett

Mean Solar Day

Modern civilization must have far more accurate chronometers than sundials are, and we must have the time on other occasions than just during "the sunny hours" of clear days. Accordingly, our clocks and methods of timekeeping are based on an average time.

We imagine a fictitious sun that glides eastward along the celestial equator (not the ecliptic along which the real sun appears to move) at a perfectly even pace. The intervals of meridian crossing from one day to the next are exactly the same for every day of the year. This fictitious sun is the *mean sun,* and the day based upon it is the *mean solar day.*

Mean Solar Time

Two factors are involved in timekeeping: the rate of the clock and the time to which it is set. The rate at which the mean sun travels is the one at which we strive to have our ordinary civil clocks operate. They keep *mean solar time.*

Local and Standard Times

Inasmuch as the sun (or the mean sun) can be on only one meridian at any one instant, observers east and west of each other do not have the same *local* time. A location only a mile to the east or west of you has a slightly different local time, and for every 15 degrees of longitude this difference amounts to an hour. (The local time concept applies to the stars also, and each observatory has and uses its own local sidereal time.)

In the United States, the confusion of local times was set in order in 1883 by a standard time system that divides the country into four zones. Standard time is the local time of a particular meridian of longitude, those of 75°, 90°, 105°, and 120° west longitude being used for Eastern, Central, Mountain, and Pacific standard times, respectively. Eastern time is an hour faster than Central; Central is two hours faster than Pacific.

Today the entire world is divided roughly into 24 time zones, although some countries do not use an even hour as their standard time. All standard time clocks are rated to keep mean solar time, and at noon a standard time clock shows when the mean or fictitious sun is on the meridian of that standard time zone.

Universal Time

Navigators, astronomers, and scientists in many fields must have a standard reference time, and this has long been adopted as that of the meridian running through Greenwich, England, where the Royal Observatory has until recently been located. The term *Greenwich civil time* has now been replaced by *Universal time,* but these two are quite equivalent. Universal time is the local mean solar time of the meridian of 0° of longitude.

In the United States, our standard clocks run slower than Universal time by even numbers of hours. Thus, to convert Universal time to Eastern standard, you must subtract five hours. For Pacific standard time subtract eight hours from Universal time.

The local time of any observer's station is also easily obtained from Universal time, for the difference is equal to the longitude expressed in time units. Thus, an observer at 92° 12′ 30″ west longitude has a local time 6 hours, 8 minutes, and 50 seconds slower than Universal time.

Equation of Time

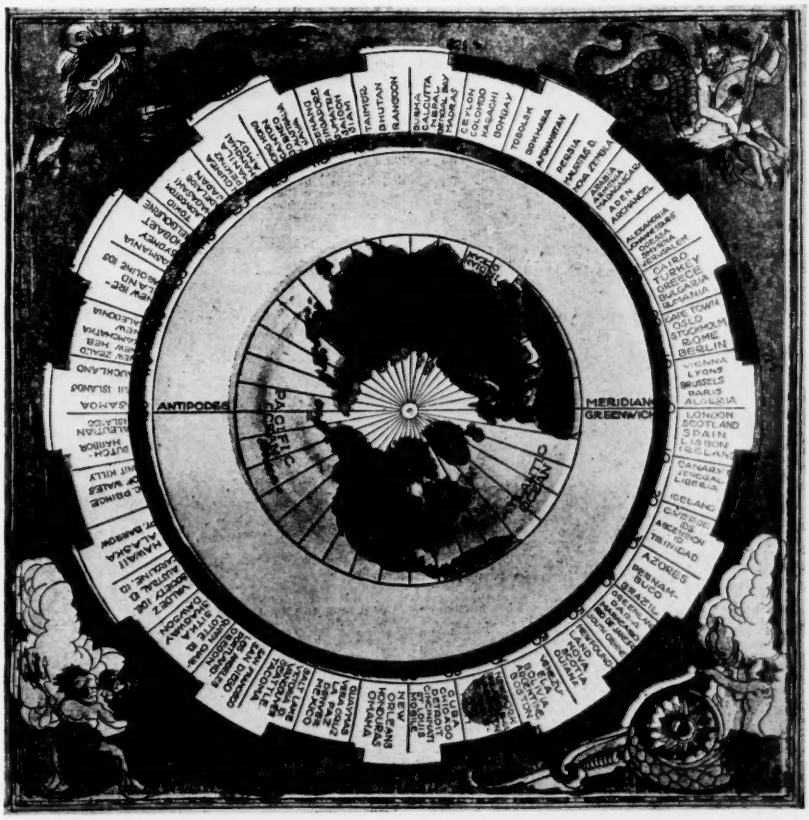
Since mean time is an average, it is clear that when a clock reading local mean time indicates noon the apparent or true sun will not always be on the meridian. At times when the sun is moving most rapidly eastward in the sky from day to day, a solar day is longer than average, and the accumulation of many long solar days will cause the apparent sun to become quite slow by the clock compared to the mean sun. At other times it will be fast, and will cross the meridian ahead of the mean sun. This difference between the times kept by the apparent and mean suns (the difference in their hour angles) is known as the *equation of time.*

There is considerable confusion as to when the equation of time should be positive or negative. The *American Ephemeris* defines this quantity as "the apparent time minus the mean time." This indicates that if the true sun is ahead of (west of) the fictitious sun, the equation of time will be positive; if behind, then it is negative. The equation of time is, then, the amount to be added — with proper treatment of signs — to the mean time to obtain the apparent or real sun time.

Scrutiny of recent astronomy texts, however, shows that while some now use the definition just given, several still have the old definition of "mean minus apparent." This changes the sign of the equation of time as given in the *Ephemeris* and requires different handling. The writer strongly favors the official usage first defined above.

On December 1st, the equation of time this year is given as $+11^{m}\ 16^{s}.22$. This means that the sun in the sky crosses the lower meridian of Greenwich about 11¼ minutes before a Universal time clock (Greenwich civil time) reads midnight. Inasmuch as the

(Continued on page 50)



Places having the same longitude have the same local time. This chart divides the globe into sections of 10 degrees or 40 minutes in local time difference.

Amateur Astronomers

AAVSO Annual Meeting and Some Highlights

THE 39th annual meeting of the American Association of Variable Star Observers was on October 13th and 14th at Harvard Observatory, Cambridge. Friday evening's speaker was Dr. C. W. Gartlein, of Cornell University, who discussed current theories of the aurora, and reported on his own observational work. Lapse-time motion pictures of northern lights displays were shown, and proved of great interest to Dr. Gartlein's audience. He concluded with colored lantern slides.

Saturday was devoted to business and paper sessions. The AAVSO president and chairman of the solar division, Neal J. Heines, discussed the condition of the present sunspot cycle. Solar activity has declined gradually but consistently this year, although the sun had not, up until the middle of October, been completely devoid of spots at any time. Mr. Heines reported that he had been able to obtain a few predictions from various persons of the date for the coming sunspot minimum, and these are quoted from his report: the National Bureau of Standards (Central Radio Propagation Laboratory), early 1955; M. Waldmeier (Zurich), 1955; W. Gleissberg (Istanbul, Turkey), not sooner than 1954; H. W. Newton (Greenwich Observatory), 1954-55; Stewart and Cook (Princeton University), 1954.6, with the further comment that 1955 will be the minimum year although 1956 is by no means precluded, and 1954 is possible if the next cycle should start hard on the heels of the current one. Mr. Heines himself gives 1954.7-1955.3.

The American relative sunspot numbers for five months of 1950 are: April, 139.5; May, 129.8; June, 99.3; July, 104.7; and August, 106.8. These were determined at the National Bureau of Standards, Central Radio Propagation Laboratory, Washington, D. C.

At the annual dinner, Dr. Harlow Shapley, director of Harvard Observatory, gave his traditional outline of some astronomical highlights of the year from November, 1949, to October, 1950. He commented on the proposed high-altitude observatory to be located in the Himalayas, three miles above sea level; on the discovery of Chubb Crater, possibly meteoritic, in Quebec; on the measurement of the diameter of Pluto using the 200-inch telescope; on the celebration this year of the centennial of the first star photograph. The work of Dr. Eugene Rabe, of Cincinnati Observatory, in determining a new value of the solar parallax, analyzing observations of Eros with punch-card techniques, and of Dr. O. J. Eggen, of Lick Observatory, in deriving highly accurate colors and luminosities for nearby stars with photoelectric methods, were discussed. The addition of Proxima Centauri to the list of four previously known flare stars, and the increase to 50 of the number of known radio stars, the latter chiefly as a result of British and Australian observations, are highlights of this past year. Among instrumental developments Dr. Shapley mentioned the initial work of the new two-mirror Schmidt telescope at Mills Observatory, St. Andrews University, in Dundee, Scotland, first instrument of its kind to go into operation.

THIS MONTH'S MEETINGS

Buffalo, N. Y.: The Amateur Telescope Makers and Observers of Buffalo will meet on December 6th and December 20th, both Wednesdays, at the Buffalo Museum of Science. On the 6th Kurt Stehling will talk on "Rockets." The second December meeting will be addressed by Raymond Missert, telling the story of "Russell Porter's Garden Telescope."

Cambridge, Mass.: The Bond Astronomical Club will meet on Thursday, December 7th, 8:15 p.m., at Harvard Observatory. Dr. Alice Farnsworth, of Mt. Holyoke College, will speak on "Moon Mapping."

Chicago, Ill.: The December meeting of the Burnham Astronomical Society will be held on Sunday, the 10th, at the Adler Planetarium at 2:30 p.m. F. W. Schlesinger, of the Adler Planetarium, will discuss "The Star of Bethlehem." Annual election of officers will be held.

Cleveland, Ohio: "An Astronomical Visit to South Africa" will be the topic of Dr. John Irwin, of Goethe Link Observatory, at the December 15th Christmas party meeting of the Cleveland Astronomical Society, at 8 p.m. in the Warner and Swasey Observatory.

Detroit, Mich.: On Sunday, December 10th, 3:00 p.m. in State Hall at Wayne University, Dr. Leo Goldberg, of the University of Michigan, will speak on "The Programs and Work of the University of Michigan Observatories," at the meeting of the Detroit Astronomical Society.

Geneva, Ill.: The Fox Valley Astronomical Society will hold its Christmas party at the Geneva public library on Tuesday, December 5th, at 8 p.m. Professor Clarence R. Smith will lecture on "Sand Dunes of Indiana."

Indianapolis, Ind.: At the meeting of the Indiana Astronomical Society on December 3rd, 2:15 p.m. in Cropsey Hall, Dr. John B. Irwin, of Indiana University, will speak on "South African Observations."

Madison, Wis.: "The Andromeda Neb-

Members and guests at the meeting of the American Association of Variable Star Observers, October 14, 1950.

ula and the Galaxy" will be discussed by Dr. A. E. Whitford, of Washburn Observatory, at the December 13th meeting of the Madison Astronomical Society, 8:00 p.m. at the observatory.

Minneapolis, Minn.: "Weather for the Man on the Street" will be discussed by W. S. Frantzich at the meeting of the Minneapolis Astronomy Club on Wednesday, December 6th, 7:30 p.m. in the Library Science Museum.

New York, N. Y.: The Amateur Astronomers Association will meet on Wednesday, December 6th, in the Roosevelt Memorial building of the American Museum of Natural History at 8:00 p.m. Dr. Willard J. Pierson, Jr., of New York University, will speak on "Ocean Waves from East Coast Storms."

On Friday, December 15th, at 8 p.m., Dr. I. Epstein, Rutherfurd Observatory, Columbia University, will speak on "Interstellar Matter," to the Junior Astronomy Club, in the American Museum of Natural History.

Pittsburgh, Pa.: N. J. Schell will speak on "Reflecting Telescope Improvements, Including Off-Axis Types," at the meeting of the Amateur Astronomers Association of Pittsburgh at the Buhl Planetarium, Friday, December 8th, at 8 p.m.

Rutherford, N. J.: The Astronomical Society of Rutherford will meet on December 7th in the Y.M.C.A. at 8 o'clock, when Paul J. Hagar will discuss "First-Magnitude Stars."

Stamford, Conn.: On December 15th, Donald S. Kimball, of Yale University Observatory, will lecture to the Stamford Museum Amateur Astronomers on "Auroral Forms and Methods of Observing," at 8:00 p.m., in the Stamford Museum.

Washington, D. C.: Dr. Carl C. Kiess, of the National Bureau of Standards, will speak on "What We Learn from Comets," before the National Capital Astronomers on Saturday, December 2nd, in the Commerce Building auditorium at 8:00 p.m.

Worcester, Mass.: William G. Fagan will address the meeting of the Aldrich Astronomical Society on Tuesday, December 5th, in the Natural History Society building at 8:00 p.m.

STARLIGHT

Starlight is a faint speech
Made dim by distance
Yet able, far diffused, to reach
Across vast ranges of existence:
Its sources are
In forces where
The motions must in fact have might
To bear an influence so far
And from all angles be so bright.

CHARLES HETZLER

THE INDEX TO VOLUME IX

of **Sky and Telescope** is in preparation. This and the indexes to previous volumes cost 35 cents each, in coin or stamps, or included in the payment of the renewal of your subscription.

SKY PUBLISHING CORPORATION
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A NEW PEOPLE'S OBSERVATORY IN SOUTH AFRICA

SOME three years ago a local center of the Astronomical Society of South Africa was formed in Port Elizabeth, and one of the initial objects was the establishment of a people's observatory. The aim was to have a small observatory with a planetarium attached, which would be an educational institution, available at all times, particularly for high school students who take elementary astronomy as a subject.

After the appointment of a board of trustees, appeals were made for public donations. The municipality of Port Elizabeth granted a site, free of cost, and a loan of £2,000 for building purposes, it being promised that the annual interest and redemption charges would be donations. Response from business firms and private individuals was very encouraging, and the firm support of other South African observatories created public confidence in the scheme.

An 8-inch refractor was purchased, and a 2-inch telescope designed by Sir Robert Gill was donated. The observatory at Cape Town donated a spectroscope and other instruments. We are working on the problems of housing the instruments, designing and furnishing a suitable lecture room, and perhaps obtaining a planetarium.

Just recently we had a visit from Dr. and Mrs. Bart J. Bok, of Harvard College Observatory, which has given valuable stimulus to the cause of astronomy in these parts.

J. C. BENTLEY, chairman
Port Elizabeth Centre
Astronomical Society of South Africa

The 8-inch refractor of the People's Observatory, Port Elizabeth, South Africa. Under date of October 30, 1950, Mr. Bentley writes, "There has been a hold-up for many months because, on the ground adjacent to the observatory site, it was proposed to erect a large football stadium, which would, of course, have entirely spoiled our view of the sky."

LEAGUE ECLIPSE CONVENTION IN NORTH CAROLINA

The Astronomical League **Bulletin** for November, 1950, reports news about the 1951 convention, to be held at Chapel Hill, N. C. Dr. Roy K. Marshall, of the University of North Carolina, has offered the facilities of the Morehead Planetarium and the university for the general convention September 1-3, 1951. Dormitory and meeting rooms are being made available. Chapel Hill is near the path of the September 1st annular eclipse.

Inasmuch as no region has been organized embracing North Carolina, G. R. Wright, chairman of the Middle East region, has been appointed 1951 convention chairman. The convention committee will include representatives of the Astronomical Society of North Carolina State College, Forsyth Astronomical Society, Greensboro Astronomy Club, and the Atlanta Astronomers, as well as Middle East regional members.

NEWS NOTES

By Dorrit Hoffleit

INDIAN RUINS AT METEOR CRATER

Discovery of arrow points and other Indian artifacts on the rim of Meteor Crater, in 1939 and 1948-49, led to archeological investigations at the crater this past summer, by the Institute of Meteoritics and the department of anthropology of the University of New Mexico. Interest in the problem was heightened by widespread belief that Indians of the Southwest held the crater in great superstitious fear.

A preliminary report was presented at the September meeting of the Meteoritical Society by Dr. Lincoln LaPaz, of the Institute of Meteoritics. Not only were numerous artifacts recovered, but several Indian ruins were discovered high on the crater rim. A one-room structure was completely excavated. This and other nearby dwellings were built of Coconino sandstone thrown out from the crater by the meteor's impact, and are estimated to have been built before 1300 A.D. Their presence within 250 feet of the crest of the crater rim "indicates clearly that the early Pueblo peoples had no fear of the Crater location," Dr. LaPaz reports. Further work is being carried on under the direction of Boyd Wettlaufer, of the university's anthropology department.

THE SHAPE OF ANTARES

It is well known that when the moon occults a bright star the effect of diffraction by the moon's limb produces a wavy pattern in the curve of the star's light as it is hidden. In other words, the occultation is not actually instantaneous, and the diffraction pattern depends partly on the apparent diameter of the star. The diameters of several stars have been measured by this method, with fast-responding photoelectric cells, by A. E. Whitford and others (see *Sky and Telescope*, November, 1946, page 7, and March, 1947, page 9).

The observed asymmetry in the light of Antares when it is occulted is much greater than predicted by theory. In 1928, H. Spencer Jones suggested that the star might be a binary, but he felt it more likely that Antares is a pulsating star. Dr. David S. Evans, of the Radcliffe Observatory, concurs with this view on the basis of observations of the occultation of Antares on June 27-28, 1950, and concludes that Antares has an ellipsoidal form with the center of brightness displaced from the center of the ellipsoidal figure. Dr. Evans found the ellipsoid to measure 0.040 second of arc, in a direction parallel to the moon's motion, and the most probable value for the minor axis is 0.027 second.

He points out, in the *Monthly Notes* of the Astronomical Society of South Africa, the desirability of repeating the occultation observations whenever possible and of using modern methods to ascertain if the star is slightly variable.

SPACE ENERGY

A "challenge to further research" was presented by Paul Scherrer, of Zurich, at the dedication of the new General Electric Research Laboratory in Schenectady recently. The amount of energy in space he estimates at some 700 million million kilowatt hours per cubic foot. Its mass alone, he contends, should produce enormous gravitational effects, such that all matter in the universe would be concentrated in a space about as large as the orbit of the moon.

Since this situation is obviously not the case, present theories are inadequate, Science Service quotes Dr. Scherrer as saying. The empty space between the stars and planets, he stated, contains 50,000 times as much energy per unit volume as the uranium used in the atomic bomb. But this energy cannot be used because it is "frozen" at the temperatures in interstellar space.

AMERICAN ASTRONOMICAL SOCIETY DECEMBER MEETING

From December 27th to 30th, Wednesday through Saturday, the 84th meeting of the American Astronomical Society will convene on the Haverford College campus, at the invitation of Dr. Louis C. Green, director of Haverford's Strawbridge Observatory. There will be business sessions and sessions for papers on Thursday and Friday, and on Saturday morning.

The fourth Russell lecture, by Dr. Harlow Shapley, of Harvard College Observatory, will be presented on Thursday evening. The title is, "The Inner Metagalaxy."

The special dinner will be on Friday evening at 6:30. Other special events include a conference on the use of planetariums in education, planned by Armand Spitz, designer of the Spitz planetarium, to be held on the 27th from 2:30 to 4:30 p.m. in the Spitz Laboratories building in Upper Darby. Demonstration of working parts of the new Spitz model B planetarium is scheduled during this conference.

Rooms and meals will be available in college dormitories for the duration of the meeting, from Wednesday evening through Saturday noon. The campus is on the Lancaster Pike in Haverford. The sessions for papers are open to interested amateurs and scientists.

Astronomers' families may attend the annual Christmas lectures at the Franklin Institute, at 4:00 p.m., December 28th and 29th, admission free. Dr. H. R. Kingston, University of Western Ontario, will give lecture-demonstrations on "Touring the Universe," the first astronomical subject for these lectures in 25 years.

SOLAR HEATING

Last winter, direct sunlight supplied three fourths of the heat needed to keep a five-room house in Cambridge, Mass., warm and comfortable. As a result of the test, scientists at Massachusetts Institute of Technology who conducted the experiment believe that a house heated 90 per cent by the sun's rays is possible without excessive construction costs, even in New England.

Water in a collector on the roof is warmed by the sun and pumped into an insulated tank; from there it passes through pipes in the room ceilings when heat is needed. Supplementary heating by electricity was required relatively infrequently. The roof heat collector unit slopes 57 degrees to the horizontal, faces directly south, and presents a net area of 400 square feet to the sun. The rest of the roof is aluminum so that additional heat reaches the collector by reflection.

COMET MINKOWSKI

Comet 1950b is now emerging from the vicinity of the sun, and its predicted magnitude (on the basis of the 4th-power law) is 10.2 on December 5th, 10.1 on the 15th, and 10.0 on the 25th. By March it is expected to be magnitude 8.9, located in Hydra at $-33°$ declination, after which it comes north again. Dr. Jorge Bobone, of Cordoba Observatory, predicts the following positions: Dec. 5, $15^h\ 03^m.3$, $-16°\ 42'$; 15, $15^h\ 03^m.9$, $-18°\ 17'$; 25, $15^h\ 03^m.5$, $-19°\ 56'$; Jan. 4, $15^h\ 1^m.5$, $-21°\ 41'$; 14, $14^h\ 57^m.2$, $-23°\ 32'$; 24, $14^h\ 49^m.5$, $-25°\ 31'$; Feb. 3, $14^h\ 37^m.4$, $-27°\ 38'$.

This comet will pass perihelion, 2.57 astronomical units from the sun, on January 15th. Its orbit is inclined to the plane of the ecliptic 144 degrees. Its nearest approach to the earth, late in March, will be about 1¾ astronomical units away.

In the CURRENT JOURNALS

STAR SPOTS? by Gerald E. Kron, **Leaflet** No. 257, Astronomical Society of the Pacific, September, 1950. "A flare that would cause an increase in solar brightness of only 1 per cent would cause a 100 per cent increase in the brightness of the M-type dwarf, and would cause a spectacular flare-up having an amplitude of 3/4 magnitude."

THE ABUNDANCE OF THE ELEMENTS, by Armin J. Deutsch, **Scientific American,** October, 1950. "Physicists and astronomers have been engaged in a cosmic inventory of the various kinds of atoms as a clue to their primordial creation."

ATOMIC AND SOLAR ENERGY, by Farrington Daniels, **American Scientist,** October, 1950. "What can our descendants use for heat and power after the year 5000 A.D.?"

The Sun's Motion Through Space

By Otto Struve, *University of California*

During the winter of 1820-21, C. F. Gauss, who was then a professor at Göttingen, gave his usual course in theoretical astronomy at the university. Among his students was a young man by the name of Kupffer, who kept careful notes of the lectures and worked them up into a manuscript under the title, "Theoretische Astronomie Gehört bei Gauss in Göttingen von May 1820 bis März 1821."

Kupffer later became a distinguished physicist. He moved to Russia and was appointed the first director of the "Principal Physical Observatory" — equivalent to our Bureau of Standards — in what was then St. Petersburg. His own work was devoted mostly to the study of the mechanical properties of various metals and to the comparison of Russian and foreign standards of measurements. He entered his lecture notes in the library of the newly founded institute. There they remained for nearly 100 years, forgotten by Kupffer and a long line of his successors. But in 1916 the post of director was again occupied by an astronomically trained scientist, A. N. Krylov, whose interest in the history of astronomy had led him to translate into the Russian language various great books of early authors, including Newton. He discovered Kupffer's lecture notes and immediately recognized their importance.

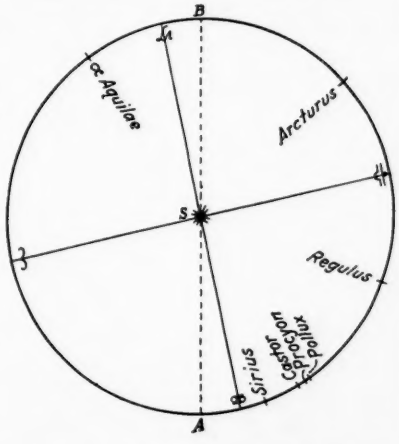
Gauss' *Collected Works* did not contain the title "Theoretische Astronomie." Since Kupffer had written down exactly word for word what Gauss had said, this document promised to throw new light upon the personality of the famous German theoretician. Krylov, who had at one time been the commander of the naval academy in Petrograd and had retained close ties with the hydrographic office of the Russian admiralty, made a translation into Russian, and in 1919 the book was printed by the hydrographic office.

Undoubtedly this book is rare. It appeared during the worst period of the civil war in Russia, when almost all connections with foreign countries were broken. A copy of it somehow found its way to Paris, and through a friendly bookseller, who is also a distant relative, I was able to buy it. It is, indeed, a remarkable account, not so much for the astronomy contained in it (which followed the traditional form of exposition in the German universities of the 19th century) as for Gauss' own, personal views concerning many controversial questions of his day. Since he was speaking to a live audience, and did not intend to have his lectures printed, he was probably less cautious and sometimes more outspoken than he would have been if he had known that one of his pupils would preserve his statements for posterity.

For example, in discussing the novae and the variables he mentions four hypotheses: the rotation of a star whose surface is not equally luminous in all its parts; the eclipse of one binary component by another which, though applicable to the case of Algol, "after all remains only a hypothesis"; and the idea of Maupertuis on the rotation of an unsymmetrical body. The fourth hypothesis is Gauss' own, "who has however never announced it." He believes that the velocity of light may be influenced by the velocity of the source and, hence, "the amount of light which reaches us in a given interval may have been radiated by the star in a very different length of time. Thus, in the case of the star in Cassiopeia (the nova of 1572) the light which was emitted over a century may have reached the earth in the course of two years." A hundred years later astronomers were still busy refuting more recent and probably independent outcroppings of this hypothesis!

But the purpose of this article is to discuss another interesting comment by Gauss. He considers the evidence that the "fixed" stars are not really fixed on the apparent celestial sphere, but that several have moved with respect to their surroundings, in the course of even as small an interval as 50 years. Gauss continues:

"Herschel believes that the solar system moves in the direction of the constellation Hercules, but later investigations are not in accordance with his hypothesis. Moreover, Herschel's method of discussion was not sufficiently mathematical. Bessel and Piazzi have reexamined this problem mathematically, but found nothing positive."

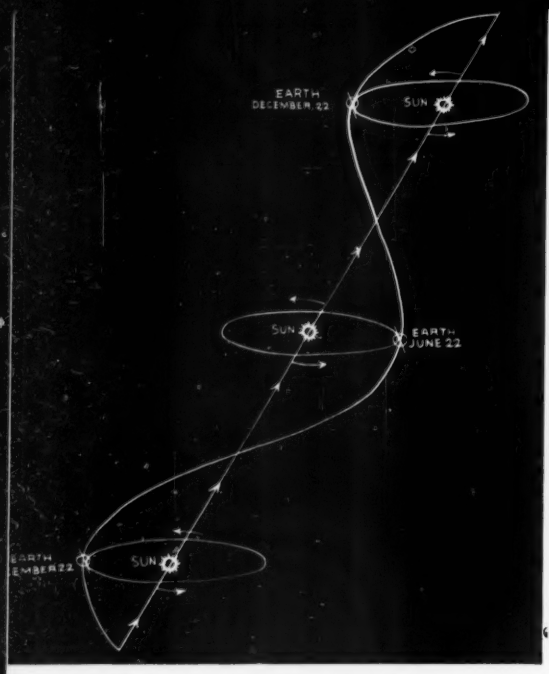


The line A-B represents that along which Herschel supposed the sun to be moving. This improved copy of his original 1783 diagram is from "A Source Book in Astronomy," by Shapley and Howarth, McGraw-Hill Publishing Co.

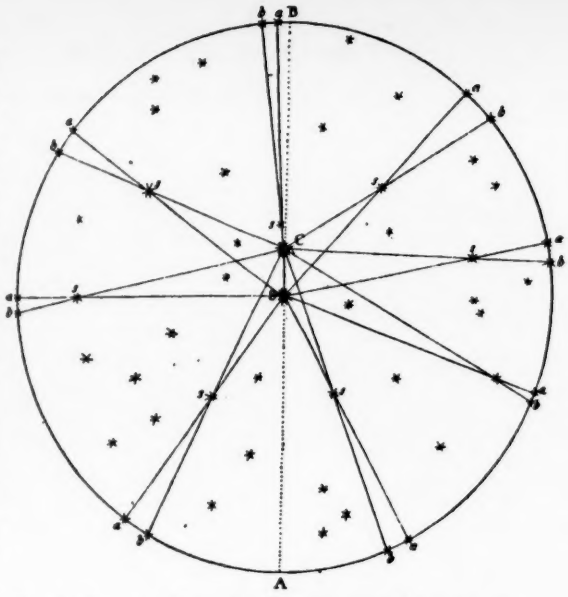
C. F. Gauss (1777-1855), generally considered (with Archimedes and Newton) one of the three greatest mathematicians in history. In 1807 he became director of the observatory at Goettingen.

This statement, made in 1820 by the greatest living theoretical astronomer, is highly surprising. Nearly every modern textbook on astronomy attributes the discovery of the motion of the solar system to W. Herschel in 1783. It was he who introduced the term "apex" to designate the point in the sky toward which we are moving; and his determination, near Lambda Herculis, is only a few degrees removed from the apex at 18 hours (270°) in right ascension and +30° in declination which is the best modern value. Surely, this was not a coincidence! The judgment of the greatest physical astronomer of his time — Herschel — was in this case superior to that of the greatest theoretician — Gauss — and of the greatest spherical astronomer — Bessel.

How did this difference in opinion arise? Herschel published three major articles on the question of the solar motion in the *Philosophical Transactions* of the Royal Society of London, in 1783, 1805, and 1806. In the first he examined the apparent angular motions in right ascension of several bright stars. Sirius, Castor, Procyon, Pollux, Regulus, and Arcturus all have decreasing right ascensions, while that of Altair increases. Herschel made a diagram representing the plane of the equator with the sun in the center. Marking off along the circle of the equator the present right ascensions of these seven stars, he noticed that if we would imagine the sun to be moving from its present position in the direction of about 18 hours in right ascension, the stars would appear to spread apart from this direction, the apex, and converge toward the opposite direction, the antapex, at six hours in right ascension. It is then easily seen that all six stars having negative proper motions (decreasing right



Left: The spiral path of the earth through space that results from a combination of its orbital motion and that of the solar system as a whole.



Right: One of Herschel's original diagrams to explain the effect of the sun's motion on the stars. They appear to move the distance on the sky a-b as the sun moves from S to C. The apex is at B, the antapex at A. Nearby stars are affected more than distant ones; this Herschel reasoned long before any star's distance had been measured.

ascension) are on one side of the circle, where the hours decrease as we pass from the apex to the antapex, while Altair is on the other side where the hours increase.

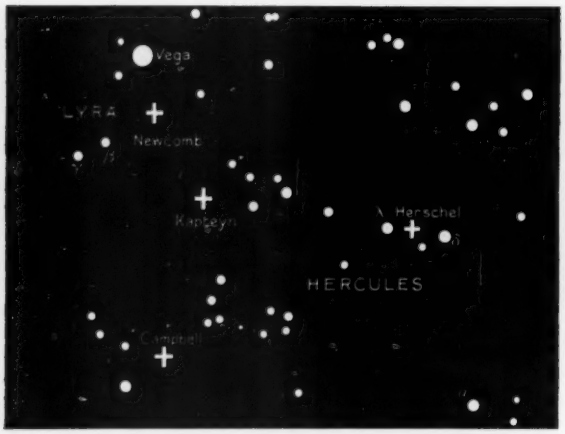
Herschel next discussed the proper motions in right ascension and in declination of 13 stars published by Lalande. To these he added the proper motion of Regulus in right ascension, giving a total of 27 values. The result is that the direction of motion is correct in 22 cases and incorrect in five, if the apex is near Lambda Herculis. The discrepancies may in part be caused by observational errors, but are more probably caused by the real motions of these stars. In a postscript, he considered the motions of stars determined by Tobias Mayer in 1756 from a comparison of his own with Ole Roemer's observations 50 years earlier. Again the agreement is very startling: 32 stars agree in direction; 12 disagree, but not one of the latter disagrees in both co-ordinates.

Herschel also attempted to estimate the velocity of the sun's motion through space. This depends upon the distances of the stars, but no parallax was then known. Assuming, on the basis of his own observations, that for Arcturus or Sirius the heliocentric parallax was equal to or less than one second of arc, he concluded that "the sun's motion cannot be less than the earth's motion in its orbit." This is a remarkably penetrating conclusion, and one of the most brilliant achievements of the human mind! We now know that the speed of the solar system through space is 20 kilometers per second, whereas the earth's orbital motion is roughly 30 kilometers per second.

In the two later papers Herschel resumed the discussion, this time using the proper motions of a list of 36 stars published by Maskelyne at Greenwich. Herschel never wavered in the belief that his 1783 results were essentially correct: "I believe the expediency of admitting a solar motion will not be called in question." Instead, he proposed to use his knowledge to "give us some useful information, either to satisfy the inquisitive mind, or to lead us on to new discoveries," and he concludes that "Arcturus still remains a star that moves with great velocity." Herschel was thus the discoverer of what we now describe as the stars of high velocity.

It must be admitted that the problem of the proper motions of the stars is not as simple as it looks. It rests upon the accuracy of the frame of co-ordinates which we use: the beginnings of right ascension and declination. These beginnings are not rigidly fixed. Because of the wobbly motions of the axis of the earth, known as precession and nutation, the pole of the heavens describes a circle in about 26,000 years. Hence the co-ordinates of all stars change slowly with time, and all astronomical catalogues contain quantities which must be added to the published star positions in order to reduce them to any given year. The proper motions of the stars are the changes in right ascension and declination that are left after the corrections for precession and nutation have been applied. If the constants of precession and nutation are inadequately known, the proper motions may turn out to be much in error. This, in substance, was the explanation of Bessel's skepticism. In 1819 he published a lengthy paper discussing precisely these sources of error in Maskelyne's observations. And while he did not disprove the results of Herschel, he apparently urged caution, which was probably justified, considering the state of astronomical observations in 1819. It is of interest that in a later lecture Bessel fully recognized the correctness of Herschel's conclusions, but that was after Argelander had repeated the work with better data and a more elaborate computing technique.

Many papers have been written since then on the motion of the solar system as determined from proper motions. Since the angular motion of a star can be measured only if it is one of our near neighbors in space, these results give us the motion of the sun with respect to the stars of our vicinity. The results



Some positions of the solar apex according to the calculations of four astronomers: Sir William Herschel, Simon Newcomb, J. C. Kapteyn, and W. W. Campbell, the first three from proper motions and the last from radial velocities. None is far from Herschel's original position near Lambda Herculis. Chart from "Splendour of the Heavens."

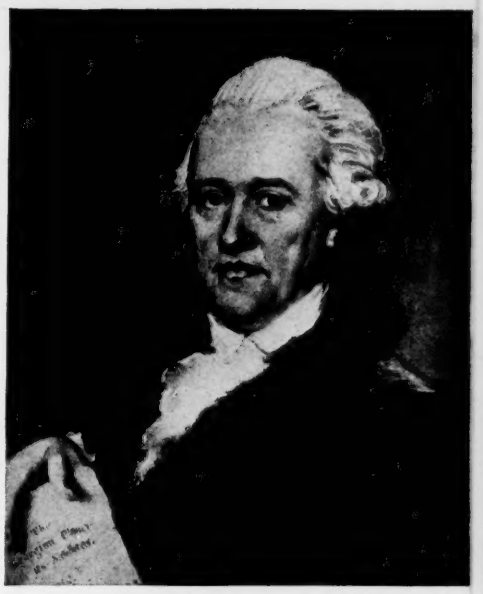
were enhanced in value when radial motions became available through the use of the spectrograph. The most elaborate determination of the motion of the sun with respect to the stars of our vicinity is that by W. W. Campbell in Volume 16 of the *Publications* of the Lick Observatory (1928). From the radial velocities of 2,149 stars he found for the apex 271° and +29°, and for the velocity of the sun 19.6 kilometers per second.

Even as the great work of Campbell was still going on at Mt. Hamilton, astronomers began to notice that the position of the apex and the velocity of the sun's motion are not the same when different stars are used. We have already seen that Herschel considered Arcturus a high-velocity star. If we pick out all the high-velocity stars and determine the sun's motion from them, the apex shifts from Hercules into Cygnus, and the velocity increases from 20 to 100 or even 200 kilometers per second. The first astronomer to consider this phenomenon systematically was G. Strömberg at Mount Wilson. His work led to what he termed an "asymmetry" of the stellar motions. The faster the stars themselves are moving in all directions, the more rapid is the sun's velocity with reference to their center of motion.

For some years Strömberg's conclusions remained quite mysterious. Their correct explanation is one of the principal contributions of B. Lindblad in Sweden. He recognized that the stars of our vicinity are not all members of what we might call a common swarm, or system. If they were, the problem of the sun's motion would be similar to that of a single mosquito in a swarm of insects. The swarm may be carried as a whole by the wind (as the galactic rotation carries the stars of our vicinity in their galactic orbits). The mosquito would not know anything about it if it could see only the other mosquitoes of the swarm. But suppose that there are two swarms penetrating through one another, and flying in different directions, with different velocities. Then our mosquito would be quite perplexed. If the two swarms consist of different species, the motion of our mosquito would turn out to be different depending upon whether the observations refer to the one species or the other.

Lindblad proposed the idea that there are different swarms of stars in our galaxy. Some revolve rapidly around the nucleus of the Milky Way and participate in the phenomenon of galactic rotation. Others belong to a system which rotates with a smaller angular velocity around the center, and still others may not rotate at all. The former are all located near the plane of the Milky Way; their rapid galactic rotation forces them to form a greatly flattened subsystem of stars. The other systems are less flattened; if we could observe the Milky Way from the Andromeda galaxy, these subsystems of stars would look like a roughly spherical, faintly luminous halo enveloping our entire galaxy.

Although much interest has attached itself to these newly discovered, spherical subsystems (of which the high-velocity stars are a conspicuous example), it must be remembered that in our vicinity the very great majority of objects belong, with our sun, to that flattened subsystem which carries us around the galactic center with a velocity of 275 kilometers per second. Hence, even now, studies of the solar motion through space — with reference to our own swarm — are of interest. The latest work of this character, by J. H. Moore and G. F. Paddock, of the Lick Observatory, has just appeared in the July, 1950, issue of the *Astrophysical Journal*. The principal result of this paper, based upon measurements of 820 stellar radial velocities, is that "the giants included in this material participate in the differential galactic rotation characteristic of the region around the sun."



Sir William Herschel (1738-1822).

The radial motions of about 1,000 stars are indicated on these hemispheres, centered on the antapex (left) and the apex. Plus signs show stars receding from us, most numerous in the antapex region. Dots represent stars approaching us, and these predominate in the apex hemisphere. From "Splendour of the Heavens."

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BOOKS AND THE SKY

L'EXPANSION DE L'UNIVERS

Paul Couderc. Presses Universitaires de France, 108 Boulevard Saint Germain, Paris, 1950. 222 pages and 10 plates, paper bound. 500 francs.

THE SCIENTISTS of France have long been renowned for their skill in popularizing science, and Dr. Couderc lives up to the reputation of his countrymen in this respect, even if his treatment of the subject of cosmology is somewhat selective. His book falls into two parts, the first 100 pages being devoted to observational methods and data, and the remainder to their theoretical interpretation.

In the first part of the work, Dr. Couderc gives a brief, but very clear and brilliantly written account of the progressive establishment of our present-day knowledge of the nature of the extragalactic nebulae, of their different types and of their distribution in space. The chapter on the measurement of distance is specially to be commended. He gives a clear account of the meaning of trigonometric, of dynamical, and of mean parallaxes, as well as of luminosity-distance, a term which he, however, does not employ. Luminosity-distance, which is deduced from the apparent and absolute magnitudes of an astronomical object, is fundamental in cosmology. Dr. Couderc does not inform his readers that, when applied to extragalactic nebulae, a trigonometric parallax (supposing it could be determined) would not necessarily give the same "distance" as that obtained from a simultaneous determination of luminosity-distance. In other words, distance in cosmology depends on the method adopted for measuring it.

A long chapter is devoted to the red shift in the spectra of the galaxies, which is interpreted as a Doppler effect. Here it is taken for granted that the observations yield a linear relation between velocity of recession and distance. In fact, what is established experimentally is a relation between red shift and apparent magnitude. To turn red shifts into velocities of recession requires a theory of the Doppler effect, and to turn apparent magnitudes into distances requires a theory of the meaning of distance as applied to objects showing pronounced red shifts and whose light takes many millions of years to reach us.

Indeed, Dr. Couderc seems to overlook the work done during the last 14 years on these difficult theoretical problems and accepts the interpretation of the relation between red shifts and apparent magnitudes current about 1935. Nevertheless, it is evident that Dr. Couderc has studied the literature, for we find on pages 93-99 that he describes Stebbins' and Whitford's work on the color indices of ellipsoidal galaxies which was published in 1948. Here we have one example of his selective method of presenting the subject; there is still another and more important instance.

Apart from a passing reference on page 20, no attention whatever is paid to Hubble's counts of nebulae published in 1936. Yet it is precisely these data which provide an observational solution of the cosmological problem, a solution whose accuracy may be expected to increase as soon as data from the 200-inch telescope are available. We must turn to the theoretical part of Dr. Couderc's book to find a possible explanation of this remarkable omission.

We have first a brief account of general relativity and of the application of this theory to the gravitational field of the sun. Much attention is thereafter devoted to the Einstein and de Sitter universes, though to most students of cosmology these universes are of little more than historical interest. These are two special cases selected from the triple infinity of model homogeneous universes predicted as possible by general relativity. A homogeneous model universe is one in which the observed irregularity of distribution of the galaxies is ignored and a strictly uniform distribution of matter is considered.

The particular model universe favored by Couderc is Lemaitre's, which is determined by the following three postulates: 1. The total mass of the model is finite and constant. 2. The model has gone through the Einstein universe stage at some time in the past. 3. The pressure of the matter in the model is zero. Lemaitre's model accounts for the assumed linearity of red shift and distance—as indeed will any other model provided that we do not look too closely into the meaning of the term "distance." But it gives a value of 9.45 x 10^8 light-years for the so-called radius of space at the moment when the model passed through the Einstein universe stage, and a present radius of about five times that amount.

On the other hand, the Hubble counts of nebulae, which are ignored by Dr. Couderc, yield the value of (5.35 ± 1.6) x 10^8 light-years for the **present** radius, a determination based on observational data together with Lemaitre's third postulate alone. Can it be that Hubble's counts are not referred to by Dr. Couderc because they do not fit Lemaitre's model of the universe?

An appendix of 10 pages is devoted to an account of the cosmologies of Milne,

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of Hoyle, Bondi and Gold, and of P. Jordan. As is usual in French books of this type, there is no index, and the bibliography is totally inadequate.

G. C. McVITTIE
Harvard College Observatory

RELATIVITY — A RICHER TRUTH

Philipp Frank. The Beacon Press, Boston, 1950. 142 pages. $2.00.

AS A SCIENTIST, I find it becoming a bit annoying—and certainly quite monotonous—to sit through at least one speech, in any gathering touching even remotely on educational problems, depicting the sad state to which the asocial character of science has brought our society.

The accusation is stereotyped: Science has cast doubt on the absolute standards that underlie our culture, and science has failed to furnish an integrated world picture that neatly ties up all loose threads. This questioning of absolute standards has weakened the measuring stick with which each new event might be isolated from its surroundings and evaluated on an individual and well-defined basis. Consequently, in times of social stress, the individual has no sense of the ethical communal ties that bind him to his fellows, and his social group is bound to collapse under strong external pressure. Thus Western Europe fell apart before the Nazis—and thus the Western world regards its weaknesses under communist pressure. Science bears responsibility for the removal of the concept of absolute standards, yet science has failed to provide an integrated philosophic scheme embracing all its positive results. Science has raised the technology of social disagreement to the level of man's understanding of the physical world, yet science has failed to provide society with a yardstick to measure itself. Hence, we are told, society must seek its own regeneration in the spirit of idealism as opposed to the materialistic-pragmatic methods of science.

The popular response among scientists seems to be one of sackcloth and ashes. All the above faults are confessed, and penance performed, by proving how even the most sophisticated scientific knowledge can be taught by osmosis at the college general education level. Simultaneously, the moan of the general educators at the lack of general philosophic integration is assuaged by allowing them full rein to "educate for democracy" and remove essentially all instruction in the methods of mathematics and quantitative reasoning below the college level.

Judged by the above standards, Dr. Frank's collection of essays should meet a general response somewhat less than enthusiastic. There is no penance in this book for the alleged difficulties brought about by science. On the contrary, Dr. Frank holds firmly to the position that the so strongly criticized rejection of absolute values embodies the strength of the scientific method. Furthermore, he suggests that the substitution of relative for absolute values in ethical matters is hardly alarming — there have never been other than relative standards!

Indeed, a discussion of this idea of absolutism in ethical standards introduces the first half of the book: an analysis of the meaning of statements. In this section, Dr. Frank covers the pragmatic-operational approach, and exhibits examples of its use in scientific developments. The scientific reader will note with pleasant surprise the smallness of the hurdle over which the author needs to pass when he progresses to the social aspects of his developments. Other readers, hoping to find in the social sciences examples of equal promise as a measure of these methods, will be pleased to note that the book finds little difference between Pierce's "a verbal difference must make an observational difference to be a difference" and the comment of an earlier Author, "by their deeds shall ye know them."

The second half of the book centers about the method of obtaining an integrated picture of our cultural development. Dr. Frank lays by the heels the old adage that philosophers must integrate what the scientists investigate. It would be an unexpected blessing if some of our education departments could be induced to take seriously Dr. Frank's mild statement, "one cannot 'unify' the language of a domain of knowledge without being thoroughly familiar with this field (of knowledge)."

The reviewer would be considerably heartened if this fine little book were made the basis of the introduction to any "course in general education." At the least, the student would then have some exposure to the usefulness of analyzing the phraseology of his "general education" in terms of the operational meaning of those phrases. Perhaps then we could justifiably hope that all variations on the phrase written by A. T. Bledsoe, and quoted as a semantic horror-lesson by Frank, "In the true sense of the word 'liberty,' slavery is not its opposite . . . ," would ever be recognized, never be accepted, in reference to either the body or the intellect.

RICHARD N. THOMAS
University of Utah

POCKET ENCYCLOPEDIA OF ATOMIC ENERGY

Frank Gaynor. Philosophical Library, New York, 1950. 204 pages. $7.50.

NUCLEAR AND ATOMIC PHYSICS are the most active branches of physics today—probably the most active branches of all science. They are currently producing a staggering volume of literature. Even for a physicist, the task of keeping abreast of progress is formidable, and for the student of a related science such as astronomy it is impossible.

The book is 204 pages of solid information with no padding. The 2,000 entries are arranged alphabetically; each is briefly defined, and numerical values are given. A sample page bears definitions of and data on: half-life; half-period; half-thickness; halogens; Hanford Engineer Works; hard radiation; Harwell; H-bomb; He; heat of radioactivity; heavy electron. There are many well-arranged tables. Besides the physical data, information about a few prominent nuclear physicists is included. German equivalents are given for the more important terms used.

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dispensable reference work on the desk of this astronomer. It cannot pretend (no book could pretend) to present the complete data of nuclear and atomic physics. The author, in a modest preface, claims only to have pointed out the "outstanding landmarks and main highways," and admits that the book will inevitably be out of date before it is distributed. With these qualifications, it is a valuable volume, whether one needs the half-lives of the unstable isotopes, a diagram of a synchrotron, the masses of the subatomic particles, the structure of a Geiger counter, or the birth date and maiden name of Madame Curie.

CECILIA PAYNE-GAPOSCHKIN
Harvard College Observatory

NEW BOOKS RECEIVED

PHOTOGRAPHY IN ASTRONOMY, *E. W. H. Selwyn*, 1950, *Eastman Kodak*. 112 pages. $2.75.

An "introduction to the practice of astronomical photography," this volume has sections on apparatus, properties of photographic materials, fine structure of photographic images, photometry, processing, and reproduction.

LATIN TREATISES ON COMETS BETWEEN 1238 AND 1368 A.D., *Lynn Thorndike*, 1950, *University of Chicago Press*. 274 pages. $5.00.

Latin medieval texts by observers of that time, with an introduction and commentary on each, and the first English translations of discussions by Albertus Magnus and Thomas Aquinas on comets, are included in this volume.

THE PRIMEVAL ATOM, *Georges Lemaitre*, 1950, *Van Nostrand*. 186 pages. $3.00.

A translation by Serge and Betty Korff of Canon Lemaitre's *L'Hypotheses de l'Atom Primitif* includes five papers and articles dated from 1929 to 1945, on the size of space, expansion, evolution, cosmogonic hypothesis, and the primeval atom.

STERNE UND STERNSYSTEME, *Wilhelm Becker*, 1950, *Theodor Steinkopff*, Dresden. 418 pages. 28 DM unbound; 30 DM bound.

A second edition of Professor Becker's discussion (in German) of the Milky Way and the external galaxies. First appearing in 1942, the book is designed to be halfway between a popular and a textbook approach.

FROM ATOMS TO STARS, *Martin Davidson*, 1950, *Macmillan*. 188 pages. $2.70.

First published in 1944, this second edition of Davidson's book appeared in 1946, under the imprint of Hutchinson's Scientific and Technical Publications. It is now available in the United States through the Macmillan Company. As the title implies, the topics are approached in general from a physical point of view, although descriptive material is included for the benefit of readers with less general background.

METEORITIC DUST, *John Davis Buddhue*, 1950, *University of New Mexico Press*, Albuquerque. 102 pages and 8 plates. $1.50.

Opening with a brief chronological resume on studies of meteoritic dust since 1819, this book proceeds to describe modern methods of study and to discuss theories on the origin of such material. This is No. 2 in the University of New Mexico publications in meteoritics.

SEVEN SCIENCE FICTION NOVELS, *H. G. Wells*, 1950, *Dover*. 1015 pages. $3.95.

During the current popular interest in science fiction magazines and books, sparked by the recent great advances in all phases of the scientific and technological fields, by news of researches in atomic physics, rocketry — and flying saucers, many aficionados are rereading books by the great master, H. G. Wells, most of them published four or five decades ago, and now out of print. This reprint of seven unabridged Wells novels was made available largely at the suggestion of the American Library Association, states the publisher, to meet the unprecedented demand for the Wells scientific romances in the libraries throughout the country. Further indication of renewed interest in Wells is the scheduled production of three biographies by various publishers.

Included in the present collection are *The Time Machine, The Island of Dr. Moreau, The Invisible Man, The War of the Worlds, The First Men in the Moon, The Food of the Gods*, and *In the Days of the Comet*.

QUAKERS IN SCIENCE AND INDUSTRY, Arthur Raistrick, 1950, *Philosophical Library*. 361 pages. $6.00.

This book is an account of the Quaker contributions to science and industry during the 17th and 18th centuries in Britain. The author traces the pattern of Quaker activity during the early years of the Industrial Revolution, and shows that by integration of Quaker family groups some of the larger industries of the 18th century emerged.

THE STAR ALMANAC FOR LAND SURVEYORS FOR THE YEAR 1951, 1950, *H. M. Stationery Office*, London. 66 pages. 3 shillings.

This is the first appearance of a special publication designed to provide information of use to surveyors, prepared under the direction of the British Nautical Almanac Office after study by a special committee during the past several years. With a preface by the Astronomer Royal, it includes an ephemeris of the sun with sunrise and sunset tables; the monthly right ascensions to the nearest tenth of a second of time and monthly declinations to the nearest second of arc of 650 stars, including all stars brighter than 4.0 and some to magnitude 4.5; a pole-star table; refraction tables; various interpolation tables; and a table for conversion of time to arc.

There is an index to the stars by constellation, making this a very practical catalogue for amateurs to use at the telescope if it is equipped with setting circles, or in conjunction with star charts and atlases.

THE NININGER COLLECTION OF METEORITES, *H. H. Nininger* and *Addie D. Nininger*, 1950, *American Meteorite Museum*, Winslow, Ariz. 144 pages plus 38 plates. $3.00.

In addition to the catalogue of meteorites in the Nininger collection, this book contains maps of western states in which numbers of falls have been located, field notes, various summaries and tables, and an unusual number of illustrations of meteorites.

TRANSACTIONS OF THE INTERNATIONAL ASTRONOMICAL UNION, Vol. VII, edited by *J. H. Oort*, 1950, *Cambridge University Press*. 552 pages. $7.50; 42 shillings.

This volume covers the proceedings of the seventh general assembly of the I.A.U., held in Zurich in 1948. It includes the minutes of the various general sessions, texts of the resolutions adopted, reports of the commissions and commission meetings, texts of the symposia presented, general information such as the statutes of the I.A.U., and lists of the membership of the entire organization, of commissions, and so on.

OUR NATURAL UNIVERSE — Including Man, *Percy A. Campbell*, 1950, *College Offset Press*, 150 N. 6th St., Philadelphia 6, Pa. 75 pages. $2.00.

The author seeks to interpret in his philosophy a great variety of natural and metaphysical phenomena.

GLEANINGS FOR ATM's

EDITED BY EARLE B. BROWN

An Efficient Synchronous Telescope Drive

PAUL B. SWEGER, of Rockford, Ill., sends the accompanying pictures and a description of his synchronous motor telescope drive.

A 3,600-r.p.m. Barber-Colman synchronous motor operates with a built-in 30,600/1 gear reduction. Thus, the output shaft makes one revolution in 8½ minutes. This shaft has a long extension, as shown in the illustrations. A 169-tooth gear on the polar axis is driven by a single-thread worm on the end of the output shaft, giving a final drive speed of one revolution in 23 hours, 56 minutes, 30 seconds, or 26 seconds slow with respect to the sidereal day. This error is useful in aiding correction for atmospheric refraction, as described by Mr. Sweger in the February, 1950, Gleanings.

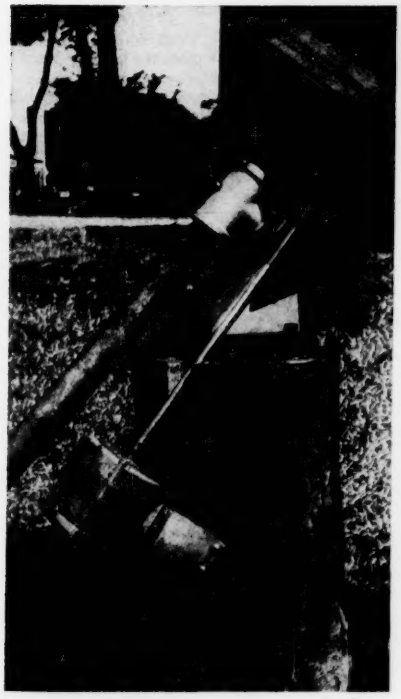
A noteworthy feature is the mounting of the output shaft at a slight angle to the plane of the polar axis gear. This keeps the motor box out of the way of the declination axis. The angle is equal to the thread helix angle of the worm; thus a straight spur gear is used on the polar axis to mesh with this worm.

The setting circles on the instrument are adapted to the mounting in the following manner. The declination circle is around the pipe flange into which the declination shaft is screwed, and is read from a pointer that extends out from the pipe tee that serves as a declination shaft bearing. A steel disk is fastened to the lower side of this tee, and there is a leather disk between the steel disk and the right ascension drive gear. This makes a disk clutch, and the weight of the telescope makes just the right amount of friction.

The right ascension graduations are around the rim of the right ascension gear and are read from two pointers that were made from little Alnico magnets. The magnets are set on the steel disk and a brass wire that is soldered to them extends out to the graduations. When the motor is first started in the evening, the telescope is pointed to some bright star and one magnet is moved around until the pointer is on the right ascension for that star. The other pointer is set on the right ascension plus or minus 12 hours. When the telescope is on one side of the mount one pointer is used, and when on the other side the other pointer is used. Once these pointers are set there is no need of any calculations to find any other celestial object because the graduations on the gear are moving at the same rate as the stars.

When Mr. Sweger is through observing for the evening, the declination shaft is screwed out of the pipe flange that is fastened to the telescope cradle, and the telescope is wheeled into the house on a cart made with two 8-inch rubber-tired wheels. A garbage can turned upside down over the mounting protects it from the weather. The base of the mounting is a tree stump.

Paul B. Sweger's reflecting telescope, operated with a synchronous motor drive that runs 26 seconds slow in a sidereal day.



This closeup of the Sweger mounting also reveals the usefulness of a tree stump as a telescope mounting support. One of the Alnico magnets is set close to the pipe tee.

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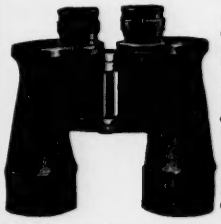

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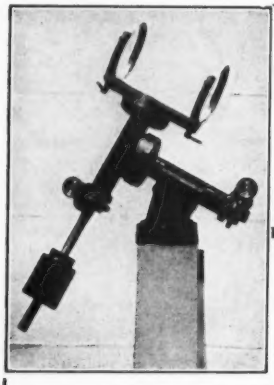

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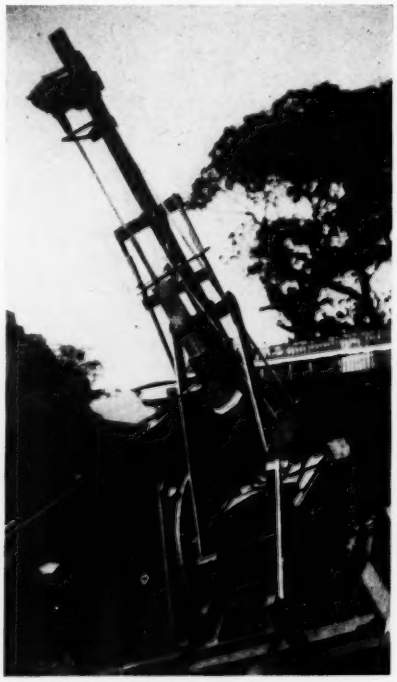
AN UNUSUAL REFLECTOR

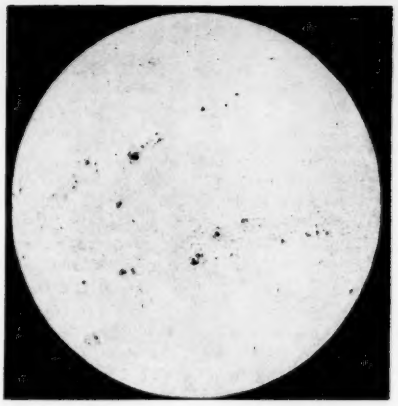
ONE of the enclosed photographs shows my telescope, an 8-inch reflector of 96-inch focus, built on the three-reflection principle. The primary is housed in the box-like arrangement. The secondary mirror is swung on a pivot in a brass fork, which in turn is pivoted on the end of the outrigger, and is controlled by rods which extend to the eyepiece end, above the primary. The third mirror is placed, at a nearly 45-degree angle, just above the primary, and facing the secondary. The eyepiece holder is a fixture immediately above the third mirror, and makes observation of objects more than 30 degrees above the horizon an easy matter, by simply looking **down** into the eyepiece. Of course, I can use two mirrors only, if needed, by removing the third mirror, and have an eyepiece pointing at the secondary. The long rods (seen in the photograph) are for collimating all the mirrors; and save a lot of trouble. The secondary mirror is about 66 inches from the primary, and the image from the secondary comes to a focus on a plano-concave lens in the focusing tube (shown in the photo) which is also controlled by a rod from the eye end of the telescope.

The other photograph is of a drawing I made at the telescope in 1947 to show detail on the sun, with the mirror stopped down to six inches. My method to obtain the drawings was to project an image of the sun about five inches in diameter and measure off all prominent spots correctly on the paper. Then I increased the focused image to about 16 inches, filling in all detail and smaller spots. I compared such drawings with some photos of the sun in your journal at the time; and I was satisfied with their correctness. They show what can be done by drawing at the telescope. The drawings are about 8½ inches in diameter, and naturally show far more detail than the photograph.

A meteor trail with a distinct curve I observed on April 15, 1950, was the most curious thing I have ever seen in my astronomical experience of over 40 years. I happened to be looking at the Hydra-Cancer region when I saw the meteor flash into sight. The trail extended from Alpha Hydrae to about 2° north of Zeta Hydrae, then, to my surprise, came to a dead stop for fully ¼ second. It then shot off at its previous speed toward Beta



Rods are used by Mr. Chapman to collimate the three mirrors of his long-focus reflector; but the secondary may be used off-axis, if necessary.



The sun on May 26, 1947, as drawn by Clive Chapman, using a projection method with his 8-inch reflector. North is at the top.

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Cancri and round past Zeta Cancri in a broad sweeping curve, gradually fading out. Its brghtness when first seen was equal to Alpha Hydrae, its color bluish, like Rigel. The length of the straight portion of the trail was about 16°, and the curved part about 22°. To say I was astonished is putting it mildly, and, believe me, I was wide awake; it was only 8 p.m.! Now what could cause the meteor to stop suddenly in its swift flight. Did it hit something? There was no sign of any extra brightness which would be caused by such a collision.

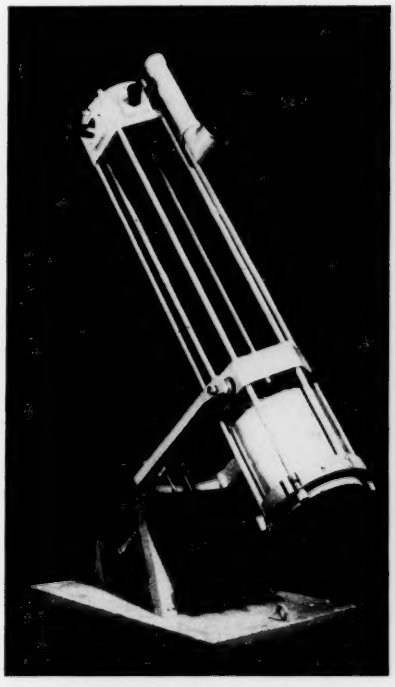
CLIVE CHAPMAN
11 Forth St., Woollahra
Sydney, Australia

A REFLECTOR FOR SWEDEN

ENCLOSED is a photograph of an 8-inch reflector which I have made for the famous Swedish sculptor, Carl Milles, who is greatly interested in astronomy. The instrument was planned with portability as a requisite. The focal ratio was therefore kept somewhat shorter than the traditional f/8, so that the eyepieces are accessible from the ground at all points.

In an attempt to combine lightness with strength and yet to avoid the expense of aluminum, the tube is made of standard steel conduit tubing such as used by electricians. Common strap iron was used for the hexagonal rings which appear at the declination axis and at each end. The fork is made of angle iron sawed one-half through at the corners and bent at right angles. The gap which was left was filled by welding a square piece of strap iron into it.

There is probably no single extra built into a telescope that makes for easier observation than a rotating tube which holds the eyepieces. This is not an easy mechanical problem for the amateur, even with a cylindrical tube. In this case, my solution was to make three eyepiece holders (the third, in the picture, is concealed behind the finder). Any power eyepiece can then be used in any of the three positions. The diagonal holder can be revolved upon its axis, and there is a dial to indicate when the diagonal is exactly facing each eyepiece.



Warner Williams' 8-inch reflector is made with steel conduit tubing.

The casters on the base support have small cranks which can be turned against the wheels to lock them when the telescope is in use.

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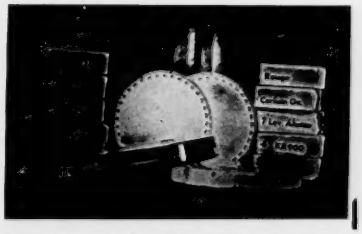

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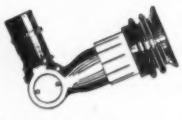

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OBSERVER'S PAGE

Universal time is used unless otherwise noted.

Configurations of Jupiter's Satellites

THE PAGEANT of Jupiter's four Galilean satellites is a never-ending one that is of great interest to the observer with a small telescope. Even modest 6x binoculars suffice to render the moons easily visible except when they are near the planet. At such times, a modest instrument allows one to note the eclipses and occultations, physical and shadow transits, which take place daily and are predicted in the **American Ephemeris and Nautical Almanac.**

On rare occasions, all four moons seem to disappear as the intervals during which they are "invisible" overlap, and the planet then seems to shine without any attendants. It is the purpose of this article to describe such circumstances and show the consequences of a very unique relation of the mean synodic periods of the first three bright satellites.

These moons revolve essentially in the plane of the planet's equator at a very small inclination to that of Jupiter's orbit about the sun. Accordingly, the orbits appear to open and close just as do Saturn's rings, although to a very much lesser extent. As a result of this small inclination, the inner three of the satellites undergo occultation and transit during each revolution, while the fourth one passes above or below the disk about half of the time.

The mean synodic periods of the moons are:

I	1.7699 days	1.0
II	3.5541 days	2.008
III	7.1664 days	4.049
IV	16.7536 days	9.466

The third column shows the period of each in terms of the first; each number is the period of the satellite in question divided by 1.7699.

It can be seen that the first three go through a cycle of a little longer than a week during which eclipses, occultations, and transits are repeated. At the end of the cycle each returns to nearly its original position with respect to the line joining Jupiter and the sun. Compare their positions on December 6, 13, 20, and 27, by examination of the accompanying chart.

Laplace first pointed out an interesting relation among the longitudes of these three satellites, defining the angle **U** as: $\mathbf{U} = \mathbf{L}_1 - 3\mathbf{L}_2 + 2\mathbf{L}_3 = 180°$. This can be seen to be true if they are arranged about the planet as in Fig. 1, where the numbers indicate the scale of longitude measured counterclockwise to 360°. For convenience, we shall have the zero of the scale always in the direction of the sun. If the periods of revolution were exactly 1:2:4, the angular velocities being the reciprocals or 1:½:¼, this relation would obviously be satisfied.

The order conceived by Laplace is a consequence of the law of gravitation. Forces tend to maintain the angle **U** near 180° so that any departure therefrom is effective as only a small oscillation. How is this possible when the periods of revolution are not exactly in the ratio of 1:2:4?

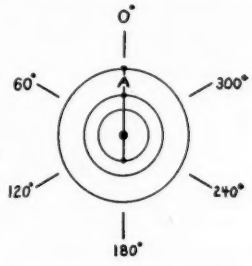


Fig. 1. The orbits of Jupiter's first three satellites are drawn to scale. "A" is the direction to the sun.

Imagine the moons to revolve counterclockwise at constant velocities, in concentric circular grooves on a disk having Jupiter at its center, and in periods which are in the above ratios. Let them be arranged along the line **A** on this disk as shown in Fig. 1. Satellites **II** and **III** are in mutual conjunction with respect to the planet, while **I** is in opposition to the others. Now follow them through a complete cycle of one revolution of **III.** Other conjunctions and oppositions of two or three satellites occur as shown in Figs. 2-8. At the end of one revolution of **III, II** has gone around twice, **I** has revolved four times, and the positions are the same as at the beginning. Note that at no time are all three satellites in line with the planet and on the same side of it.

Next superimpose upon these motions

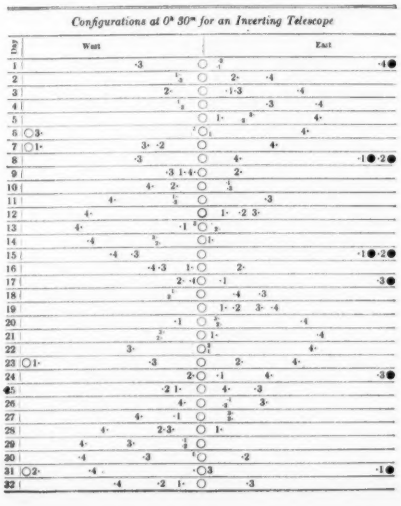
UNIVERSAL TIME (UT)

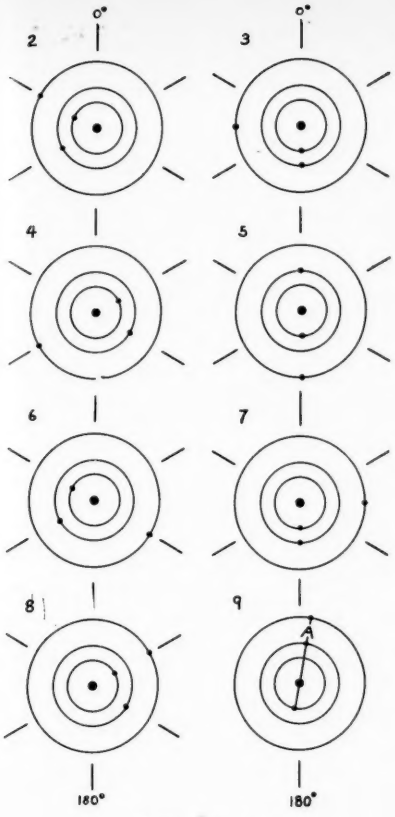
TIMES used on the Observer's Page are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, and the result is your standard time on the day preceding the Greenwich date shown.

JUPITER'S SATELLITES

Jupiter's four bright moons have the positions shown below for the GCT given. The motion of each satellite is from the dot to the number designating it. Transits of satellites over Jupiter's disk are shown by open circles at the left, and eclipses and occultations by black disks at the right. Reproduced from the **American Ephemeris and Nautical Almanac.**

Configurations at 0h 30m for an Inverting Telescope





Figs. 2 to 9.

a slow clockwise rotation of the disk. The moons will now line up along **A** a little before **III** has completed one revolution, as in Fig. 9. Since the innermost revolves fastest, it will complete four revolutions first, then **II** will complete two revolutions, and finally **III** will return to zero longitude while the others will have gone farther.

Let us pause to consider the actual configurations that are listed in the almanacs, referring to Fig. 1 again. Since the sun lies in the direction of zero longitude, the shadows of **II** and **III** are on the central meridian of Jupiter's illuminated disk while **I** is at mid-eclipse behind the planet. The former are at heliocentric inferior conjunction while the last is at heliocentric superior conjunction. Whenever a moon is at 90° or 270° longitude, it is at greatest elongation from the planet as seen from the sun. For example, in Fig. 3, **I** and **II** are in eclipse while **III** is at greatest elongation.

If the earth is directly between Jupiter and the sun, the planet is at opposition, and the terrestrial observer sees the same phenomena at the same time as an imaginary solar observer. In Fig. 1, satellites **II** and **III** are at the midpoint of physical transit while **I** is occulted and lies behind Jupiter midway between immersion and emersion. When the planet is not at opposition, there is a lead or a lag in the times of occultation and physical transit with respect to eclipse and shadow transit, respectively.

Now let us determine the effect of the slow clockwise rotation of our imaginary disk. The formula for determining the period (**S**) that elapses between consecutive mutual conjunctions of any two satellites is $1/S_{12} = 1/P_1 - 1/P_2$, where P_1 is the mean synodic period of **I**, and P_2 is the mean synodic period of **II**. This is analogous to the equation for determining the synodic period of a planet, where the given data are the sidereal periods of the earth and planet.

We find that S_{12} is 3.5255 days, or about one half of S_{23}, which is 7.0509 days. The fraction of a synodic revolution that **III** has completed at the end of 7.0509 days is 7.0509/7.1664, or 0.9839. The remainder, $1 - 0.9839 = 0.0161 = 1/62.07$, represents the fraction of the circle that the line **A** has rotated clockwise to bring the time of conjunction of **II** with **III** a little earlier than a complete revolution of **III**, in Fig. 9.

When **A** has rotated an entire 360°, it will again point in the direction of the sun, and circumstances of eclipses and shadow transits will be repeated. This will take place in 62.07×7.0509, or 437.6 days. Dividing this by 365.24, the number of days in a year, gives 1.198, which is virtually 1.2 years, a very interesting result.

On our imaginary disk with its circular grooves, the azimuths at which two or more of the moons line up with Jupiter are at intervals of 60°, or 1/6 of a circle. Therefore, at periods of $1/6 \times 1.2$, or 0.2 year, each azimuth in turn will coincide with the direction of the sun, and there will be simultaneous eclipses and/or shadow transits of two or three satellites. These occur during seasons at present near the following five dates:

Feb. 17, May 1, July 13, Sept. 24, Dec. 6.

Each configuration will occur at the next later season in successive years until at the end of six years (five complete cycles) it will have returned to the same one as before. Two such periods elapse in 12 years, a trifle longer than the time required for Jupiter to make a revolution about the sun. Many a reader will recognize the similarity to the circumstances which cause the aspects of Venus to take place near certain dates over an eight-year cycle.

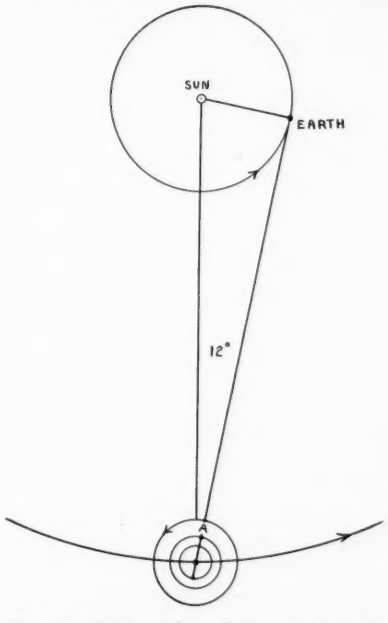


Fig. 10. The orbits of the earth and Jupiter are drawn to scale; the satellite orbits are to a different scale.

This month the direction of **A** coincides with that of the sun on the 6th. On page 440 of the **American Ephemeris** are tabulated the eclipse of **I** and the shadow transits of **II** and **III**. **I** emerges from eclipse at 6:23 UT. Midway between the times of ingress and egress, the shadows are near the central meridian of Jupiter's disk. These come at 5:17 for **II** and 5:22 for **III**. A little earlier, the two shadows will pass each other east of the center. This should be a fine sight for telescope observers in the western United States.

At that time there will be a noticeable separation of the moons themselves, they having moved off the planet's disk at different times somewhat earlier. These circumstances afford a good opportunity to see what happens when the earth, sun, and Jupiter are not in the same straight line. When Jupiter is at quadrature, as happened on November 21st, the earth is at greatest elongation from the sun as seen at the planet. This is about 12°, and it remains nearly at maximum during early December. The result is that all physical transits precede shadow transits when Jupiter is an evening star. Similarly, all occultations precede eclipses. When the planet is in the morning sky, the reverse is true.

Furthermore, when Jupiter is in the evening sky, the direction of **A** on our imaginary disk does not point toward the earth until some days after it points to the sun. Fig. 10 illustrates the situation when the planet is at quadrature and physical transits of **II** and **III** coincide with occultation of **I**.

Study of the table on page 440 of the **American Ephemeris**, together with the chart facing it that is reproduced here, will show that on December 7-8 the moons line up as in Fig. 3. These phenomena will be easily observed in the early evening in the eastern part of the country. On the 9-10, they appear as in Fig. 5, while on the 11-12, they are as shown in Fig. 7. At all of these times, **I** is in eclipse, and the scene for terrestrial observers shifts eastward a trifle less than a quarter of the way around the world from each time to the next. This is a consequence of the period of **I** being a little longer than 1.75 days.

The line **A** points toward the earth on December 18th, when **I** and **II** are behind the planet and **III** is at greatest elongation east. The nearest approach to the conditions of Fig. 10 comes on the 20th, although the earth has by that time advanced a little farther in its orbit than is shown in the diagram. Nearly simultaneous disappearance of the three moons may be observed in the eastern Pacific.

Conditions under which all four of the Galilean satellites are "hidden" at the same time are satisfied only rarely. They do not follow any simple relationship such as has been demonstrated for the first three. This may be expected, since the period of **IV** is not anywhere near commensurate with the others. Examination of the table in this article shows this to be true.

Of course, the four moons cannot all

be "hidden" except at such times as the direction of **A** is nearly toward or away from the earth and the orbits are sufficiently closed so that the fourth satellite does not miss the disk (or is in eclipse). The last time this took place was on March 4, 1949. The writer saw a near disappearance of all four on July 29, 1948, when **IV** was at close superior conjunction on the south side of the planet, with **II** and **III** in transit, and **I** occulted.

Finally, a variation of great interest to the observer with binoculars is the simultaneous greatest elongation of the three inner moons. This occurs when **A** is at right angles to the direction of the earth. At such seasons the moons stand out brilliantly on the same night each week for at least two months. Because of its great distance and long period, the fourth satellite may also be seen on most of these occasions. This will next take place in March, 1951, but then the planet will be overwhelmed by the sun's rays. The moons will be seen to fine advantage the following period, during the months of October and November of next year.

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Visual Observing Programs for Amateurs — IX

Instrumental Limitations

DAWES' LIMIT. W. R. Dawes, "the eagle-eyed" astronomer of the last century, determined the closest double star separation theoretically resolvable as 4.56 seconds of arc divided by the aperture (in inches) of the telescope. Thus with a 6-inch telescope, be it reflector or refractor, one may expect under good conditions to separate two stars which are only 0″.76 apart.

In my youth I was able to see stars 0″.6 apart with my Clark 6-inch refractor, but I do not seem able to do better than about 2″ nowadays with my 6-inch reflector, using 229x. For about 19 out of each 20 seconds of time I cannot separate such a star, but intermittently it is suddenly seen clearly and widely separated. Other amateurs report somewhat similar experiences here in New England, such as, for instance, intermittent views of double stars with a separation of 2″.4 with a 9.4-inch reflector, using 90x, and 2″.2 with a 6-inch reflector, using 105x. This relatively poor performance of reflectors is undoubtedly caused by the unsteady seeing in this region, which seems to affect reflectors much more than it does refractors.

Narrowest Line Visible. In some recent naked-eye tests made for the Association of Lunar and Planetary Observers, I was able to see a wire, against the sky, which subtended an angle of only 3″ at my eye. At the same time I was able to separate an artificial double star of about 240″ separation, center to center. The ratio is 80 to 1, so that Dawes' limit is enormously larger than the narrowest line one can see. With a 6-inch telescope at 300x, allowing for atmospheric troubles, telescopic imperfections, and lack of contrast on Mars, I estimate that I can see on the mottled yellowish surface of that planet a dark line, say green or blue or brown, 20 miles wide. This would be at an opposition when Mars' disk subtends an angle of 14″. Such a line would subtend an angle at the earth of only 0″.067, about 1/11 of Dawes' limit for a 6-inch telescope. Others can no doubt do much better. Percival Lowell made tests on wires seen against the sky, and based on these he thought he could detect lines on Mars only a mile wide with his 24-inch Flagstaff refractor, but my tests indicate that a dark line which appears against a mottled surface is not as visible as a dark line against a bright sky, so it is probable that Lowell's estimated limit of visibility is too small.

Magnitudes. We use the magnitudes of stars, meteors, comets, satellites, and planets, in much of our work, so it is well to review what is meant by the term magnitude.

Bright stars are usually referred to as being of the 1st magnitude. Actually there is no specific star of this brightness. Altair at 0.9 and Aldebaran at 1.1 magnitude come as close to it as any. The faintest star the eye can see is usually referred to as being of the 6th magnitude. A star of 1.0 magnitude appears 100 times as bright as a star of magnitude 6.0. If we study these figures with a table of logarithms we will discover that any star gives 2.512 times as much light as a star one magnitude fainter, and 1.0965 times as much light as a star 0.1 magnitude fainter than itself. For ordinary purposes we can consider these ratios as 2.5 and 1.1.

Nowadays we are all familiar with watts, because electric light bulbs are rated in watts, so the following approximate analogy may make matters clearer.

Magnitude	*Watts*	*Magnitude*	*Watts*
8.0	1.5	2.0	400
7.0	4	1.0	1,000*
6.0	10*	0.0	2,500
5.0	25*	−1.0	6,000
4.0	60*	−1.1	6,600
3.0	150*		

*Electric light bulbs come in these sizes

It will be noted that as one drops five magnitudes anywhere in the table the wattage goes up 100 times, and that a change of 0.1 magnitude between the last two items corresponds to a 10 per cent change in wattage.

Faintest Star Visible. The following table shows the theoretical limits of the faintest stars that can be seen with certain sized refractors. It also shows the actual results obtained by various members of the AAVSO who live in New England, both with refractors and reflectors, and some estimated points based on their actual results.

Inches of Aperture	*Refractors*		*Reflectors*
	Theoretical Limit	*Actual Results*	*Actual Results*
12	14.6	15.3†	14.6†
10	14.2	14.9†	14.2†
9.4	14.1		14.1*
8.75	13.9		14.1*
8	13.6	14.3†	13.6†
6	13.1	14.0*	13.5*
5	12.7	13.4†	
4	12.1	12.8*	11.7*
3.5	11.9	12.8*	11.9†
3	11.6	12.1*	
2.75	11.4	11.8*	

* Actually seen by AAVSO members in New England

† Estimated points based on above

Those with better seeing or keener eyes can perhaps better the results shown in the last two columns by a fraction of a magnitude. It will be noted that the faintest star actually visible with a 6-inch refractor is about as faint as that actually visible in reflectors of around 9 inches aperture. It may be that in climates with steadier seeing reflectors would do better.

Testing Your Telescope. If you do not feel that your telescope is giving good results do not hesitate to test it. It is easy to give a reflector a rough knife-edge test at its focus. Do not use a star because the cut-off is too quick. Use Jupiter, Mars or Saturn, or Venus if gibbous. This tests not only the mirror but the secondary and the atmosphere in the tube as well, which sometimes shows up as a cold current of air falling alongside the tube wall and oozing out like molasses over the mirror. However, if the whole ensemble has a good figure and the atmosphere is not too troublesome, one should get a flat cut-off.

Both reflectors and refractors can be tested quite well by using a fairly high-power eyepiece, focused on a star, such as Polaris, and then moving the eyepiece both inside and outside focus and examining the resultant images seen. If they are not truly circular, then something is seriously wrong. The telescope may need realignment, or there may be strains in the mirror or objective caused by a tight or poor fit in the cell, or other troubles may be indicated.

If you have previously tested the mirror or objective for figure when in its cell and tube, you need do no more than make an occasional quick test as above after each time that the instrument receives an inadvertent bump. However, the inside and outside focus tests can be used also to check the figure and achromatism of the objective or mirror. For explanations of how to interpret these images, see Bell's **The Telescope, Amateur Telescope Making,** third edition, p. 428, or other works.

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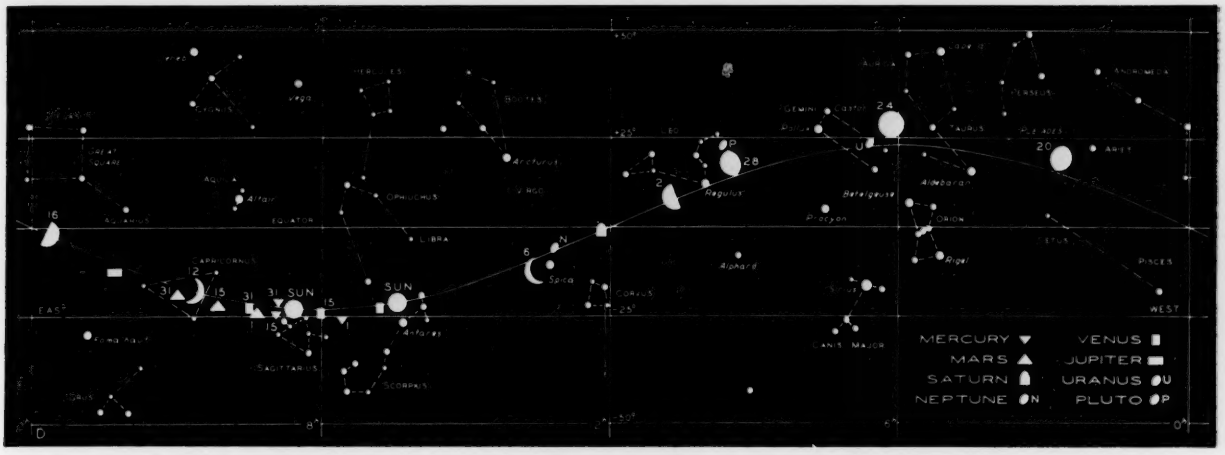
FIREBALL OVER NORTHEAST

At 7:33 p.m. EST, on Thursday, November 2nd, a fireball was seen from Montreal to Washington, D. C., and from Maine to Syracuse, N. Y. Newspaper identification of the flash as a rocket seems improbable; it was reported by many as equal to the light of the full moon.

While observing galaxies in Ursa Major, James Wesling, of Parsippany, N. J., noticed a "bright reddish flash, lighting the whole sky with a greenish blue light." Its azimuth was between 30° and 34° east of north.

At Logan Airport in Boston, the control tower saw a white streak, very bright, moving from around the zenith westward. Airplane pilots reported also that a red or brown streak persisted for five or 10 seconds after the meteor passed. No flares were observed and no explosions heard. The meteor apparently passed westward over New England into New York State and Canada. Overcast conditions were general west of Albany.



THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month and for other dates shown.

Mercury remains in the evening sky all month, attaining maximum eastern elongation on December 15th, 20° 29′ from the sun. This is the seventh elongation of Mercury this year. The usual number is six, but roughly every fourth or fifth year there is an extra elongation. On the 15th, Mercury sets about 1½ hours after the sun and is of magnitude −0.2. Careful observation will reveal the elusive planet from the 1st to about the 25th.

Venus, in the evening sky since last month, emerges sufficiently far from the sun to become visible at the end of December. Look close to a clear horizon near the sunset point shortly after the sun has set; you may see Venus only about 12 degrees from the sun.

Earth will reach heliocentric longitude 90° on December 22nd at 10:14 UT. Winter commences in the Northern Hemisphere and summer begins in the Southern Hemisphere.

Mars continues its rapid eastward motion, setting 2½ hours after the sun. Remaining of the 1st magnitude, Mars is nevertheless inconspicuous because of its nearness to the sun.

Jupiter, on the meridian at sunset December 22nd, sets five hours later. It remains the brightest object in the night sky, just outshining Sirius. The Jovian disk is 38″ in diameter at the equator, an excellent object for smaller telescopes. A special article on Jupiter's satellites appears elsewhere in this department.

Saturn, found in the morning sky after midnight, remains one of the best objects for telescopic study. The rings appear inclined 4° to our line of sight, with the northern face visible. The major diameter is 39″, and the minor is 2″.8, compared to the planetary disk of 16″. Saturn is located near Eta Virginis and is of magnitude +1.2 on the 15th.

Uranus comes to opposition with the sun on December 29th, at a distance of 1,663 million miles from the earth. The planet will be in the sky all night, visible with slight optical aid; it appears as a 6th-magnitude "star" about 2½° southwest of Epsilon Geminorum, as shown on the chart on page 98 of the February issue.

Neptune may be located with a small telescope during the early morning hours. It is moving eastward about 1½° southeast of Theta Virginis and is of the 8th magnitude; a chart of its path is on page 98 of the February issue.

NOTE: On or about December 25th, the five naked-eye planets may be viewed between sunset and midnight. Venus, Mercury, Mars, and Jupiter are less than 90° east of the sun in that order. Saturn, at western quadrature, rises about midnight and will be the lone bright planet visible for the remainder of the night.

E. O.

DECEMBER METEORS

Recent observations made by the British Astronomical Association have shown the Geminid meteor shower to vie with the Perseids as the richest annual meteor display. Predicted rates are 60 per hour, best before midnight. The shower may be observed from the 9th to the 14th, with its maximum on December 12th. As the moon is new on the 9th, its light will not interfere this year. The radiant of the Geminids is near the star Castor, at 113°, + 32°, and is of the multiple-center type. Geminids are of medium speed, generally white, and many bright and trained meteors appear.

A shower newly discovered by the British observers, the December Ursids, is at maximum on the 22nd. The full moon will hamper observations. The radiant is at 207°, +74°, near Beta Ursae Minoris, with predicted rates of 12 per hour.

E. O.

MINIMA OF ALGOL

December 3, 7:22; 6, 4:11; 9, 1:00; 11, 21:49; 14, 18:38; 17, 15:27; 20, 12:17; 23, 9:06; 26, 5:55; 29, 2:44; 31, 23:33. January 3, 20:22.

These predictions are geocentric (corrected for the equation of light), based on observations made in 1947. See **Sky and Telescope,** Vol. VII, page 260, August, 1948, for further explanation.

OCCULTATION PREDICTIONS

Data for the occultation of Gamma Cancri on December 26-27 was published in the November issue.

DEEP-SKY WONDERS

THE GALAXY NGC 628, M74, at $1^h\ 34^m$, +15° 32′, is an Sc spiral, about 8′ x 8′ in size, and of magnitude 11.2. It appeared on the back cover of the March, 1950, **Sky and Telescope.**

Although bright enough to be included in Messier's famous catalogue, M74 is not conspicuous. Smyth does not include it in his **Celestial Cycle** (1844), and neither does the Reverend Webb in his **Celestial Objects for Common Telescopes** (fourth edition, 1881).

One word of caution may be given here about these two books—they do not use today's constellation boundaries, as drawn, for instance, in Norton's **Star Atlas,** recent editions of which employ the new official boundaries adopted by the International Astronomical Union in 1930.

NGC 253, 1^s, $0^h\ 45^m.1$, −25° 34′, is a galaxy about 22′ x 6′, of magnitude 7, which the NGC catalogues as a fine object, very bright and large, and considerably brighter toward the center. A photograph of it appeared on the front cover of the May, 1946, issue. The object is mentioned by Smyth but not by Webb. It was originally discovered by Caroline Herschel, whose talents have been too much overshadowed by those of her illustrious brother.

WALTER SCOTT HOUSTON

PHASES OF THE MOON

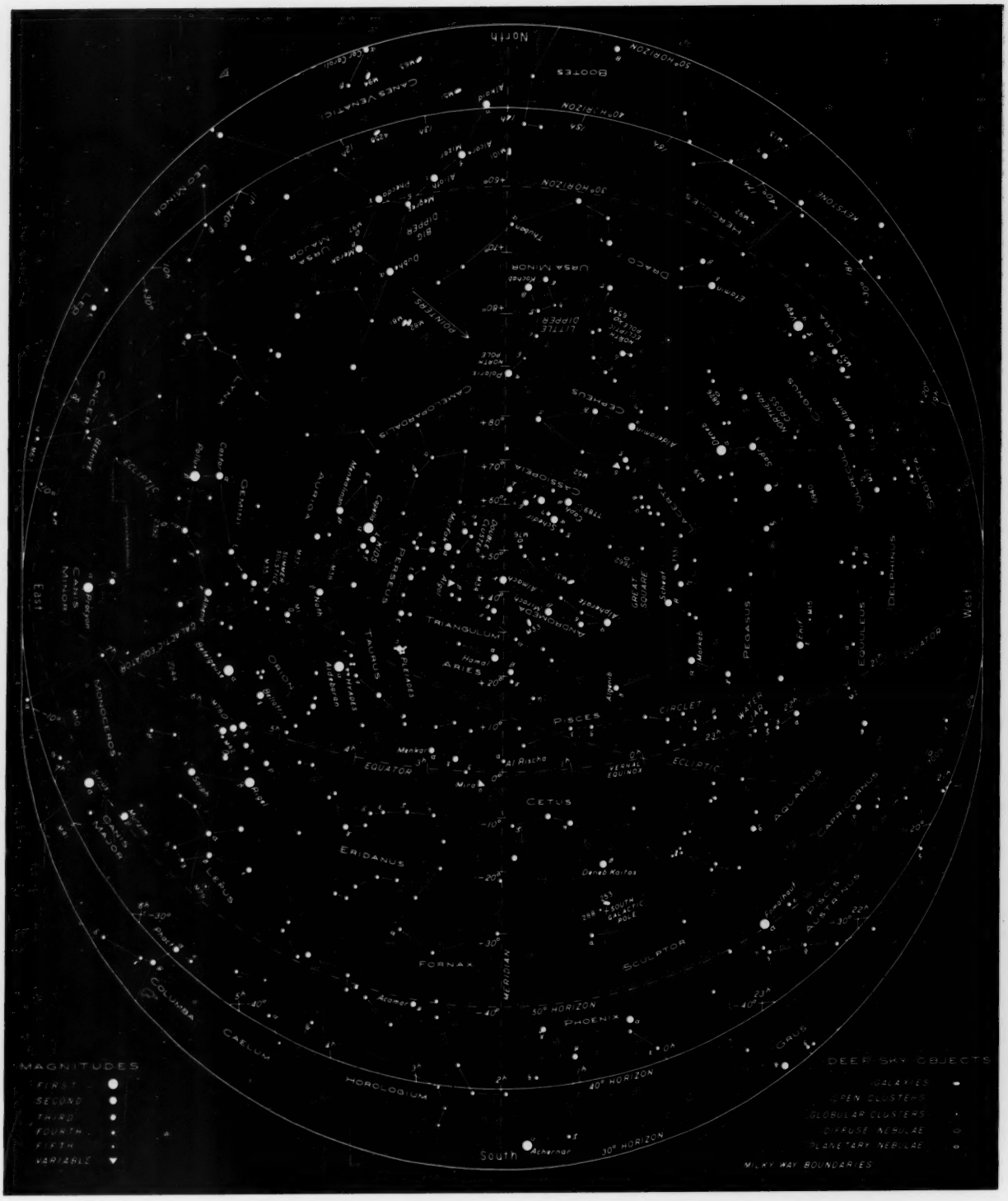
Last quarter	December	2,	16:22
New moon	December	9,	9:28
First quarter	December	16,	5:56
Full moon	December	24,	10:23
Last quarter	January	1,	5:11

	December		Distance	Diameter	
Perigee	9^d	1^h	221,700 miles	33′	29″
Apogee	22^d	2^h	252,400 miles	29′	25″

VARIABLE STAR MAXIMA

December 19, R Reticuli, 7.7, 043263; 21, RT Hydrae, 7.6, 082405; 24, R Aquilae, 6.3, 190108.

These predictions of variable star maxima are by Leon Campbell, honorary recorder of the AAVSO. Only stars are included whose mean maximum magnitudes, as recently deduced from a discussion of nearly 400 long-period variables, are brighter than magnitude 8.0. Some of these stars, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the predicted magnitude, and the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern).



The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of December, respectively.

STARS FOR DECEMBER

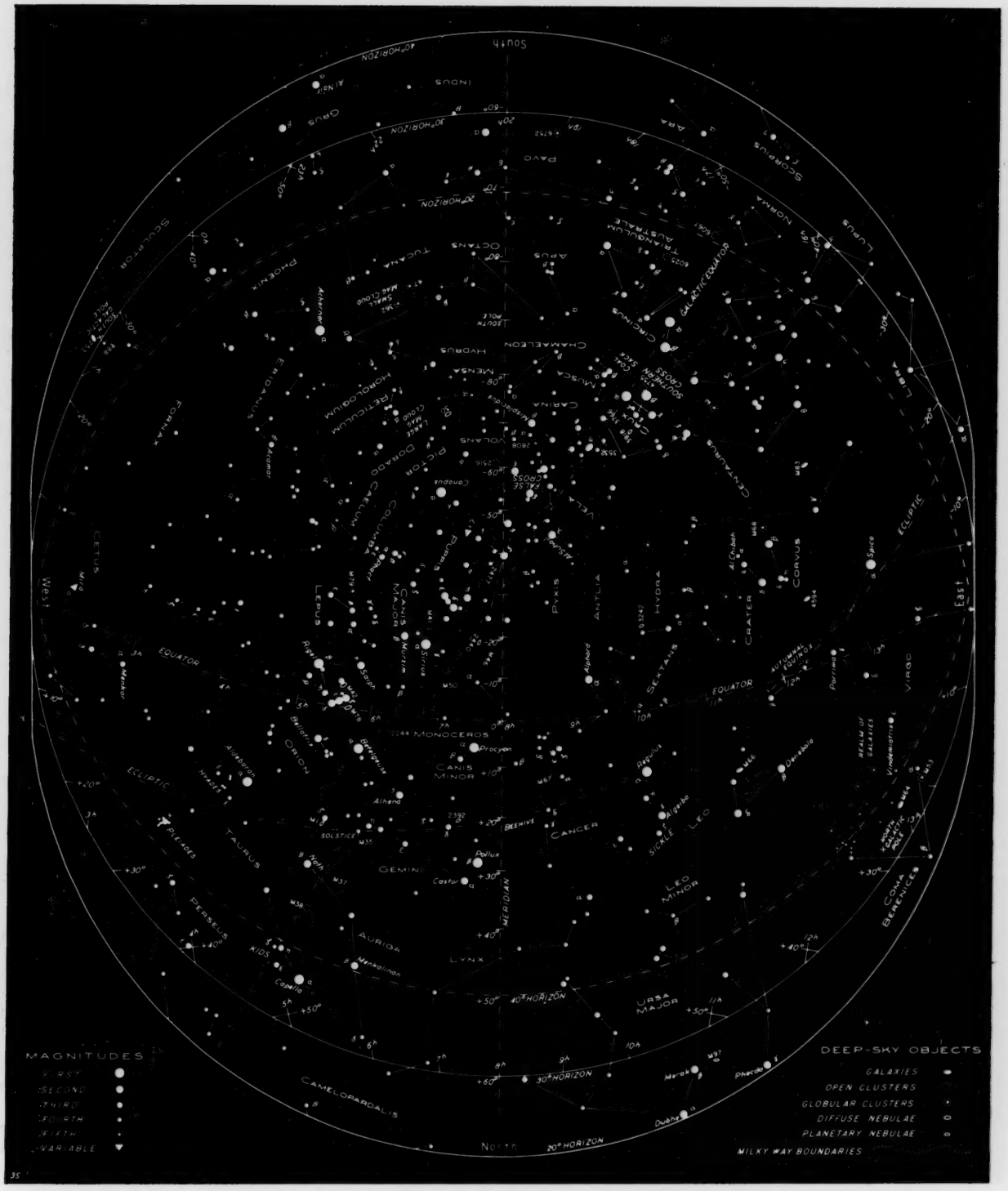
GLITTERING brightly overhead in early winter evenings is the armor of Perseus. Famous as the home of Algol, the constellation also contains the Double Cluster, the radiant of the August meteors, and Nova Persei 1901. The Double Cluster is easily seen visually as a haze halfway between Alpha Persei, Marfak, and Delta Cassiopeiae, Ruchbah. The Demon Star itself, Algol, is pictured as in the head of Medusa, held by Perseus.

For information on when Algol is near its minimum, see page 47.

Andromeda's mother, Cassiopeia, is just west of Perseus in the Milky Way. Curiously enough, both Alpha of this group and the central star of Cygnus come directly from the Arabic word for breast; however, Alpha Cassiopeiae is spelled Schedir, while Gamma Cygni is Sadr. Beta in Cassiopeia is Caph, meaning hand.

A small group of mediocre stars west of Cassiopeia was named Lacerta by Hevelius during the 17th century. Apparently the ancients imagined a foreleg of Pegasus in this region, since Pi Cygni, east of M39 and across Lacerta from Pegasus, bears the name Azelfafage, the hoof of the horse.

OWEN GINGERICH


South
North
East
West
MAGNITUDES
FIRST
SECOND
THIRD
FOURTH
FIFTH
VARIABLE
DEEP-SKY OBJECTS
GALAXIES
OPEN CLUSTERS
GLOBULAR CLUSTERS
DIFFUSE NEBULAE
PLANETARY NEBULAE
MILKY WAY BOUNDARIES
ECLIPTIC
EQUATOR
MERIDIAN
SOUTH POLE
GALACTIC EQUATOR
SOUTHERN CROSS
MAGELLANIC CLOUDS
ORION
TAURUS
GEMINI
CANCER
LEO
VIRGO
LIBRA
SCORPIUS
OPHIUCHUS
SAGITTARIUS
CAPRICORNUS
AQUARIUS
PISCES
ARIES
CETUS
ERIDANUS
AURIGA
PERSEUS
LYNX
URSA MAJOR
LEO MINOR
COMA BERENICES
CANES VENATICI
BOÖTES
CORONA BOREALIS
HERCULES
LYRA
CYGNUS
AQUILA
DELPHINUS
PEGASUS
ANDROMEDA
CASSIOPEIA
CEPHEUS
DRACO
URSA MINOR
CAMELOPARDALIS
LACERTA
CANIS MINOR
MONOCEROS
HYDRA
CRATER
CORVUS
CENTAURUS
LUPUS
NORMA
ARA
PAVO
INDUS
GRUS
PHOENIX
TUCANA
OCTANS
HYDRUS
CHAMAELEON
MUSCA
CRUX
CARINA
VELA
PUPPIS
PYXIS
ANTLIA
SEXTANS
CRATER
CORVUS
CANIS MAJOR
COLUMBA
PICTOR
DORADO
RETICULUM
HOROLOGIUM
ERIDANUS
FORNAX
SCULPTOR
CETUS
LEPUS
20° HORIZON
30° HORIZON
40° HORIZON
Sirius
Canopus
Rigel
Procyon
Betelgeuse
Aldebaran
Capella
Pollux
Castor
Regulus
Spica
Arcturus
Antares
Vega
Deneb
Altair
Fomalhaut
Achernar
Hadar
Alpheratz
Markab
Schedir
Diphda
Menkar
Algol
Mirfak
Dubhe
Merak
Phecda
Alioth
Mizar
Alkaid
Polaris
Kochab
Rasalhague
Alphecca
Shaula
Kaus Australis
Nunki
Ascella
Altair
Deneb
Vega
Albireo
Gienah
Alderamin
Enif
Markab
Scheat
Algenib
Almach
Hamal
Alpheratz
Mirach
Sheratan
Mesarthim
Alpha Arietis
Menkar
Ankaa
Achernar
Acamar
Zaurak
Rigel
Betelgeuse
Bellatrix
Mintaka
Alnilam
Alnitak
Saiph
Wezen
Adhara
Sirius
Canopus
Miaplacidus
Avior
Suhail
Alphard
Regulus
Algieba
Denebola
Zosma
Chertan
Coxa
Porrima
Vindemiatrix
Spica
Alkaid
Mizar
Alioth
Megrez
Phecda
Merak
Dubhe
Kochab
Pherkad
Polaris
Alpha Cephei
Alderamin
Errai
Caph
Schedir
Navi
Ruchbah
Segin
Algol
Mirfak
Atik
Menkalinan
Capella
Elnath
Alcyone
Atlas
Electra
Maia
Merope
Taygeta
Pleiades
Hyades
Aldebaran
Rigel
Bellatrix
Betelgeuse
Alnilam
Alnitak
Saiph
Mintaka
Procyon
Gomeisa
Alhena
Wasat
Castor
Pollux
Asellus Australis
Asellus Borealis
Acubens
Altarf
Algenubi
Algieba
Regulus
Denebola
Zosma
Chertan
Coxa
Porrima
Vindemiatrix
Spica
Arcturus
Alphecca
Nusakan
Unukalhai
Zubenelgenubi
Zubeneschamali
Brachium
Acrab
Dschubba
Antares
Rasalhague
Sabik
Yed Prior
Yed Posterior
Cebalrai
Rasalgethi
Kornephoros
Sarin
Vega
Sheliak
Sulafat
Deneb
Albireo
Gienah
Alderamin
Enif
Fomalhaut
Deneb Adige
Sadalsuud
Sadalmelik
Skat
Markab
Scheat
Algenib
Alpheratz
Caph
Schedir
Mirach
Almach
Hamal

A Proposal for the Christmas Star

THE STORY of the Wise Men from the east seeing a star, and then making the long journey to Palestine to pay homage to the child Jesus, is one of the best known of the Christmas stories. The Wise Men are also called the Magi, and sometimes the three kings. The visit is commemorated in the festival of Epiphany, celebrated on January 6th.

Some assume that this "star" was a miraculous light, not explainable by the laws of nature. Others assume that a perfectly natural phenomenon aroused the interest of the Wise Men. Still others dismiss the entire story as a myth. This note is for the benefit of those who assume the "star" was a natural event. Suggestions are that it may have been a conjunction or close grouping of two or more planets, a bright comet, a brilliant meteor, or a nova. The scriptural narrative (*Matthew* II) indicates that the "star" was something almost or altogether outside the previous experience of the Wise Men, that it was seen once in their eastern country and again at Bethlehem, that it was regarded as a good omen, and that it seemed to stand over the house where the child was found.

The requirement that it must have been a relatively new experience for the Wise Men rules out a conjunction or close grouping of planets, since they should have seen several such. The two appearances separated by a considerable time interval rule out any single comet, meteor, or nova. The fact that it was regarded as a good omen seems to eliminate the comet and meteor, which were thought to foretell the death rather than the birth of a king.

Let us now rewrite the story on the assumption that someone in the community where the Wise Men lived nearly 2,000 years ago found the planet Venus in the western sky one clear day at about noon. This star in the daytime sky was something quite unheard of by the Wise Men, or by anyone else in the community. Yet a person with normal eyesight could see it quite easily once he had found it, and could point it out to others. The Persians and the Jews of that day were both expecting a messiah, or great king, and the Wise Men interpreted this daytime star in the western sky as announcing the birth of a messiah to the west, or to the Jewish people. Eventually they made the long journey to see the newborn king, going first to Jerusalem for information, and then to Bethlehem.

As the Wise Men approached Bethlehem, they naturally thought about the star that had started them on the long journey, and on reaching the inn they looked for it. Being close to all the houses in Bethlehem, they assumed that the daytime star would be close to overhead. As is often the case for Bethlehem (latitude 31°.7 north), Venus was so close to the zenith that to the ordinary observer it seemed exactly overhead. One of the Wise Men found it "standing over" the inn, and they assumed at once that the child must be in the inn.

We might accept the tradition associated with the Well of the Magi at Bethlehem, which is that one of the Wise Men went to the well of the inn to draw water. He saw the star (Venus) reflected in the clear water of the well in daytime, and knew the star must be nearly overhead. This told the Wise Men they were at the right place.

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Planetarium Notes

BALTIMORE: *Davis Planetarium.* Maryland Academy of Sciences, Enoch Pratt Library Building, 400 Cathedral St., Baltimore 1, Md., Mulberry 2370.
SCHEDULE: 4 p.m. Monday, Wednesday, and Friday; Thursday evening, 7:45, 8:30, 9:30 p.m. Admission free. Spitz projector. Director, Paul S. Watson.

BOSTON: *Little Planetarium.* Boston Museum of Science, Science Park, Boston 14, Mass. Richmond 2-1410.
SCHEDULE: Tuesday thru Friday at 3:30 p.m.; Saturday, 2:00 and 3:30 p.m.; Sunday, 3 and 4 p.m. Spitz projector. In charge, Charles A. Federer, Jr.

BUFFALO: *Buffalo Museum of Science Planetarium.* Humboldt Parkway, Buffalo, N. Y., GR-4100.
SCHEDULE: Sundays, 2:00 to 5:30 p.m. Admission free. Spitz projector. For special lectures address Elsworth Jaeger, director of education.

CHAPEL HILL: *Morehead Planetarium.* University of North Carolina, Chapel Hill, N.C.
SCHEDULE: Daily at 8:30 p.m.; Saturday and Sunday at 3:00 p.m. Zeiss projector. Director, Roy K. Marshall.

CHICAGO: *Adler Planetarium.* 900 E. Achsah Bond Drive, Chicago 5, Ill., Wabash 1428.
SCHEDULE: Mondays through Saturdays, 11 a.m. and 3 p.m.; Sundays, 2:30 and 3:30 p.m. Zeiss projector. Director, Wagner Schlesinger.

KANSAS CITY: *Kansas City Museum Planetarium.* 3218 Gladstone Blvd., Kansas City 1, Mo., Chestnut 2215.
SCHEDULE: Wednesday and Saturday, 3:30 p.m.; Sunday, 3:00 and 5:00 p.m. Spitz projector. Director, Charles G. Wilder.

LOS ANGELES: *Griffith Observatory and Planetarium.* Griffith Park, P. O. Box 9787, Los Feliz Station, Los Angeles 27, Calif., Olympia 1191.
SCHEDULE: Wednesday and Thursday at 8:30 p.m.; Friday, Saturday, and Sunday at 3 and 8:30 p.m.; extra show on Sunday at 4:15 p.m. Zeiss projector. Director, Dinsmore Alter.

NEW YORK CITY: *Hayden Planetarium.* 81st St. and Central Park West, New York 24, N. Y., Endicott 2-8500.
SCHEDULE: Mondays through Fridays, 2, 3:30, and 8:30 p.m.; Saturdays, 11 a.m., 2, 3, 4, 5, and 8:30 p.m.; Sundays and holidays, 2, 3, 4, 5, and 8:30 p.m.; Wednesdays and Fridays, 11 a.m., for school groups. Zeiss projector. Acting Chairman, Robert R. Coles.

PHILADELPHIA: *Fels Planetarium.* Franklin Institute, 20th St. at Benjamin Franklin Parkway, Philadelphia 3, Pa., Locust 4-3600.
SCHEDULE: Tuesdays through Sundays, 3 p.m.; Saturdays, 11 a.m.; Saturdays, Sundays, and holidays, 2 p.m.; Wednesdays, Fridays, and Saturdays, 8:30 p.m. Zeiss projector. Director, I. M. Levitt.

PITTSBURGH: *Buhl Planetarium and Institute of Popular Science.* Federal and West Ohio Sts., Pittsburgh 12, Pa., Fairfax 4300.
SCHEDULE: Mondays through Saturdays, 2:15 and 8:30 p.m.; Sundays and holidays, 2:15, 3:15 and 8:30 p.m. Zeiss projector. Director, Arthur L. Draper.

PORTLAND, ORE.: *Spitz Planetarium.* Oregon Museum of Science and Industry, 908 N.E. Hassalo St., Portland 12, Ore., East 3807.
SCHEDULE: Tuesday through Sunday, 4:00, 7:30, and 8:30 p.m.; Saturday show for tots, 10:30 a.m. Special group lectures by request. Spitz projector. Director, Stanley H. Shirk.

SPRINGFIELD, MASS.: *Seymour Planetarium.* Museum of Natural History, Springfield 5, Mass.
SCHEDULE: Tuesdays, Thursdays, and Saturdays at 3 p.m.; Tuesday evenings at 8 p.m.; special star stories for children on Saturdays at 2 p.m. Admission free. Korkosz projector. Director, Frank D. Korkosz.

STAMFORD: *Stamford Museum Planetarium.* Courtland Park, Stamford, Conn.
SCHEDULE: Sunday, 4:15 p.m. Special showings on request. Admission free. Spitz projector. Director, Robert E. Cox.

TERMINOLOGY TALKS

(Continued from page 31)

equation of time is changing constantly, for noontime the same exact figure will not apply, and for other locations than the Greenwich meridian interpolation in the *Ephemeris* tables must be made.

This month is one in which a great change in the equation of time takes place, for it is reduced to $5^m\ 14^s.78$ on December 15th; on Christmas Day it is practically zero, and the sun in the sky and a local time clock are in agreement; and by the end of the month the apparent sun lags behind the mean sun by about three minutes.

The greatest extremes possible for the equation of time are given generally as $-\ 14^m\ 28^s$ on February 11th and $+\ 16^m\ 24^s$ on November 3rd, these dates varying slightly with the calendar.

The Analemma

Corrections are often given on sundials for various dates in order to reduce the readings to mean time. They may take the form of what looks like an odd figure 8, the *analemma,* and this figure is often included on terrestrial globes (usually somewhere in the Pacific Ocean area of the globe). The analemma gives in simple fashion the equation of time for any day of the year, and it also shows the variation in the sun's declination during the year.

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